PEARL

The Journal of HEREDITY

AN ALBINO COCKER SPANIEL
(SEE PAGE 103)

Hybrid Vigor in Sorghum
Crossing over in Neurospora
Origin of Fancy Mice in the Orient
Genes and Cancer-producing Agents in Mice
A New Lethal Gene in Dairy Cattle
Twins With Tuberculosis
Eugenical Sterilization

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TWICE AS TALL AND THREE TIMES AS PRODUCTIVE AS ITS PARENTS

Frontispiece

An extreme instance of hybrid vigor is this remarkable hybrid between Hegari Sorghum (right) and Dwarf Broomcorn (left). The hybrid was more than two and one-half times as tall and produced nearly three times as much forage and grain as either of its parents. Precautions were taken to insure uniformity of cultural conditions so that this difference represented a true genetic effect, and not a difference in environment.

HYBRID VIGOR IN SORGHUM

R. E. KARPER and J. R. QUINBY
Texas Agricultural Experiment Station

HETEROSIS is a common phenomenon in first generation hybrids of many species of plants. The theory that accounts for hybrid vigor generally accepted by geneticists is that of Jones[4] who explained the phenomenon as being due entirely to the bringing together in the first generation hybrid of a large number of dominant genes favorable to growth and development, some of which are contributed by one parent and some by the other. Linkage of genes and the large number involved practically prevent the perpetuation of the vigor in the same degree in later generations. This theory, which is postulated on a strictly genetic basis, has recently been reviewed by East[3] who presents an inclusive bibliography on the subject.

The results of a study of vigor in certain sorghum hybrids have been reported by Conner and Karper,[1] and in view of the marked hybrid vigor found in these crosses, it was thought to be desirable to determine the magnitude of the vigor that could be obtained from crossing certain additional varieties with one another with the view of determining the most favorable combinations to use in connection with the production of crossed sorghum seed in sufficient quantities for field plantings.

Crosses Studied

Sorghum (*Sorghum vulgare*, Pers.) is a self-pollinated species, in which hybridization has been accomplished by hand emasculation and pollination. More recently a method of emasculation with hot water has been used and by this method crossed seed in considerable quantity has been obtained. In this study, F_1 populations of thirty plants were grown along with rows of the parent varieties and observations of growth and maturity, measurements of plant characters, and determinations of yield of grain and forage were made. The necessary precautions were taken to insure reliability of the results; for instance, constant rows of a single variety separated each row upon which measurements were taken so as to reduce or eliminate the effect of competition. All plants were spaced uniformly eighteen inches apart in the row. Standard deviations were computed for each character of each population studied so that the significance to be attached to the various differences between means might be determined.

Cultivated sorghums are of many types; the different varieties are indigenous to widely separated parts of the world; the various types have different uses to man; and some varieties have only recently been introduced into cultivation while others have been used since ancient times. On the basis of their use the cultivated sorghums can be classified into grain, forage, grass, and broomcorn types, but all belong to the same species as they have the same chromosome number,[5] and are completely inter-fertile. There was no way to predict the vigor of the F_1 of any particular cross, so crosses were made between milo, kafir, Hegari, feterita, kaoliang, sorgo, and broomcorn. Measurements were made of plant height, number of nodes, length and width of leaf, diameter of stalk, number of stalks, and yield of stover, heads, forage, and grain; also, date of maturity was observed.

These hybrids were grown in both 1932 and 1934 at the Texas Substation at Chillicothe. The data are too voluminous to be included in this paper, and only data for some characters of certain hybrids grown in 1932 are included. The results for the two years are in almost perfect agreement.

DEGREE OF HETEROSIS DIFFERS IN EACH CROSS

Figure 1

This series shows three degrees of hybrid vigor exemplified in various crosses. The cross of Hegari × Blackhul kafir is extremely tall and late in maturity. There is a large increase in forage and grain yield in hybrids of this type. The hybrid produced by Hegari and feteria (*B*) is more rank growing, and late in maturing. Hybrids 15 feet tall and yielding 150 bushels of grain to the acre have been obtained in combinations of this kind. Vigor in grain and forage production with no great increase in height is shown in the feterita × Blackhul kafir (*C*). Such less spectacular hybrids, which mature at the same time as popular varieties, have more promise for practical utilization than the tall, rank-growing, late maturing forms.

Many Different Degrees of Hybrid Vigor

All of the hybrids were more vigorous than either of their parents. The most evident expressions of hybrid vigor obtained were increased vegetative growth and extreme lateness of maturity. There was a range in vigor, however, from slightly greater than that of the parents to the extreme vigor that resulted in plants fifteen feet tall and grain yields that were above 150 bushels per acre. Milo and Hegari always contributed extreme vigor and lateness to the hybrids, whereas other varieties contributed vigor without the expression of extreme height or lateness. For the purpose of simplifying the discussion, the hybrids used have been arbitrarily divided into four groups arranged in accordance with the magnitude of vigor expressed in the F_1 (Frontispiece and Figures 1*A* and 3.)

Crosses Between Varieties Giving Maximum Vigor

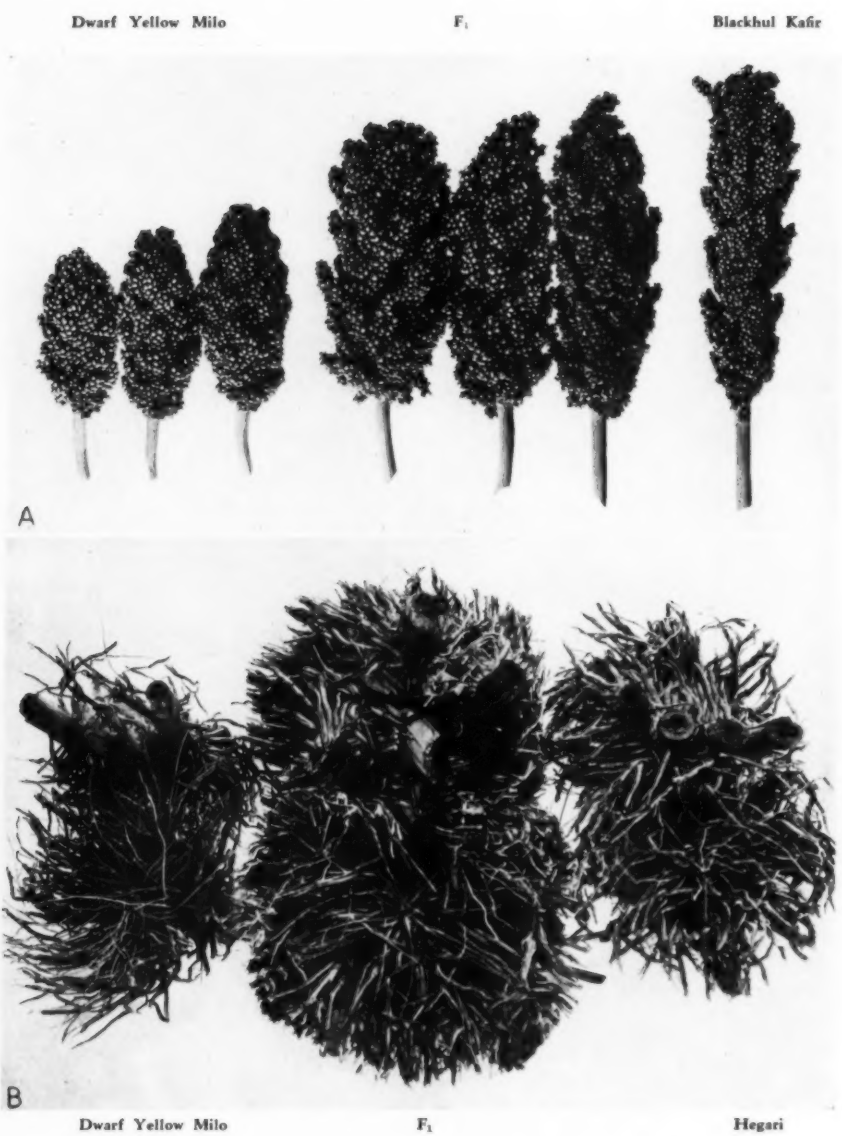
Some of the parental combinations produced hybrids that showed extreme vigor in the F_1 generation. Although the parents of these extremely vigorous hybrids were dwarf varieties, the F_1 generation grew to a height of twelve to fifteen feet (Frontispiece and Figure 1*A*), and production of grain (Figure 2*A*) and forage was enormously increased. In several instances the hybrids produced between two and three times as much as the most productive parent (Table I). It will be noted that either milo or Hegari was one of the parents in every cross that produced maximum vigor in the F_1 generation, irrespective of which variety was used as the other parent. When milo and Hegari were intercrossed the magnitude of vigor was no greater than that of other combinations of crosses where milo or Hegari was only one of the parents. Evidently these two varieties have not only many dominant genes in common but between them possess a majority of the favorable dominants to be found in the genetic makeup of any one or all of the sorghums used as parents in these crosses.

The unusual height is apparently due to the complementary action of a relatively few genes that influence peduncle length, internode length, and number of nodes. Height of plant, however, is only one of the expressions of vigor apparent in this class of crosses. One of the most striking evidences of heterosis is rank vegetative growth as shown by large stalks, excessive tillering, large dark-green leaves, and extensive development of the root system (Figure 2*B*). It is apparent, therefore, that commercial varieties of sorghum are recessive for a number of genes deleterious to growth in addition to those responsible for dwarfness of plant. It is this fact that affords opportunity for selection of superior strains following hybridization.

It was a surprise to find when certain of these hybrids were grown that they were so extremely vigorous, indicating wide genetic difference between varieties which were assumed to be quite closely related. It had been assumed, for instance, that there was a close relationship between feterita and Hegari as they came from the same general region of Africa, possessed the same genetic complex of seed characters, and otherwise resembled each other rather closely. Judging these two varieties by the vigor of their hybrid (Figure 1*B*) they are distantly, rather than closely, related as the F_1 hybrid possessed all of the characteristics denoting extreme vigor (Table I) including tallness, large stalks, large leaves, extreme lateness, and high yield of grain and forage. This hybrid in 1932 produced 126 bushels of grain to the acre, which was approximately two and one-half times that of the higher producing parent. It is apparent, therefore, that the few visible characteristics that make two varieties resemble each other are not an adequate basis from which to draw conclusions concerning differences in genetic makeup.

Crosses Between Varieties Giving Intermediate Vigor

The hybrids falling in this class are of especial interest because there is a tendency for hybrid vigor to be expressed



VIGOR OF SEED HEADS AND OF ROOTS OF DWARF YELLOW MILO HYBRIDS

Figure 2

Comparable heads of parent and hybrids of Dwarf Yellow milo and Blackhul Kafir (*A*), and roots of Dwarf Yellow milo and Hegari (*B*). The vigor of the hybrid extends to all parts of the plant. The large root system is adequate to nourish giant hybrid plants which often produce large amounts of grain.

in production of grain and forage with much less evidence of vigor expressed in height, or in lateness, than occurred among the above hybrids whose parents seem to differ widely in their genetic complex. The parents of the hybrids included in this group are Blackhul kafir, Spur feterita, and Sumac. These varieties are visibly different in many respects but their F_1 hybrids indicate that they differ genetically by only a few genes that affect vegetative growth. Notwithstanding the dissimilarity of these varieties in appearance, the hybrids are not extremely vigorous (Figure 1*C*), indicating that the few genes responsible for visible differences do not necessarily contribute much to vigor in the F_1. The vigor of these hybrids is expressed in somewhat greater vegetative growth but not in lateness of maturity. Hybrids with any two of these varieties as parents, although taller than the parents, are not extremely tall. The production of grain is approximately twice that of the parents.

Since we know each of the parents of the hybrids in this group is recessive for a number of genes the dominant allelemorphs of which are present in milo or Hegari, and since these varieties when inter-crossed do not produce hybrids of the very vigorous type, it is evident that kafir, sumac, and feterita have many recessive genes in common. These varieties do differ by enough genes, however, to produce in the hybrids a grain yield double that of the parents. This increase in grain yield is proportionately greater than the increase in vegetative growth. It appears likely that the supplementary effect of a few genes that affect the various vegetative characters such as length and width of leaf, leaf number, etc., is in large measure responsible for the large increase in grain yield of the hybrids without the vegetative characters of the hybrid greatly exceeding those of the largest parent.

Earliness is one of the distinguishing characteristics of the F_1 hybrids in this group. Here are examples of vigor in sorghum that resemble hybrid vigor in corn where a common characteristic of F_1 hybrids is their earliness. It is fortunate that lateness does not always accompany hybrid vigor in sorghum as earliness will be important in the hybrids that may eventually be distributed for commercial planting.

Crosses Between Closely Related Varieties

The striking thing about the hybrids between these closely related varieties is that the parents are recessive for the same height factors but differ in enough other genes so that there is considerable increase in production of grain and forage in the hybrid. The two varieties, Dwarf Yellow milo and Dwarf White milo, have in the past been described as differing only in the gene that affects pericarp color, seed color being practically the only visible difference between these two varieties. It is now quite apparent that Dwarf Yellow milo is homozygous for a number of recessive genes deleterious to growth and production not possessed by Dwarf White milo and vice versa. The F_1 hybrids of this cross produced slightly more stalks per plant than either of the parents and this fact alone could account for the increased yield in the F_1 generation. The extra tillers in the hybrids may be due to supplementary factors for tillering brought in from the two parents or it may be due entirely to the stimulation brought about by the supplementary action of a number of genes each having a minute effect.

Blackhul and Red kafirs are visibly more different than are Dwarf Yellow and Dwarf White milos, nevertheless they are quite similar. The production of grain of the hybrid of these two kafirs was more than twice that of the highest yielding parent, but since the parents are homozygous for the same genes for dwarfness, this large increase in production of grain was not accompanied by added height (Figure 3). In this cross the F_1 hybrids also produced more stalks to the plant and in addition each head, on the average, produced more grain. It

LARGE GRAIN YIELD IN HYBRIDS BETWEEN CLOSELY RELATED FORMS

Figure 3

The F_1 hybrid (center) between two closely related varieties, Blackhul kafir (left) and Red Kafir (right) is no larger than the parent forms. The hybrid produces slightly more tillers than the parent varieties, but yields of grain twice that of the more productive parent variety have been produced by this cross.

is clear that the increase in yield of hybrids of sorghum is not caused alone by the same genes that influence height. Unquestionably, sorghum varieties are homozygous for a good many recessive genes deleterious to growth and development other than genes for dwarfness. It is this fact that makes the prospect for the commercial growing of first generation sorghum hybrids so promising.

Crosses Between Inbred Lines

Fortunately ideal parental material for this combination of crosses between inbred lines was available from a long and continuous experiment in inbreeding of sorghum. The inbred lines of Blackhul kafir used as parents in these crosses had been inbred for 16 generations. At the end of the second year of selfing these lines were uniform and apparently homozygous, and continued inbreeding did not further change the type or visibly reduce the vigor.[2] These inbred strains resemble one another closely but do possess enough visible differences so that progeny rows of the different lines can be distinguished if grown side by side.

Although there were small visible differences between the F_1 hybrids and their parents, there was no measurable difference found in height of plant and other vegetative characters. There was, however, a slight increase in grain and forage yield, in some cases as much as

10 per cent. The data show that in these hybrids the increased production was brought about largely through an increase in number of stalks to the plant, for, as in the case of crosses between closely related varieties, the hybrids had a greater tendency to tiller.

Hybrid Vigor in Endosperm Development

Heterosis is also shown by increased growth of the endosperm of crossed seeds and the increased size of endosperm is correlated with the expression of vigor in the F_1 plant. Three heads of Schrock, a variety having waxy endosperm, were emasculated with hot water and were pollinated as follows:

1. With a mixture of Schrock and Blackhul kafir pollen.
2. With a mixture of Schrock and milo pollen.
3. With a mixture of Schrock and Hegari pollen.

The waxy seeds of the three heads were, therefore, pure Schrock and the non-waxy seeds were hybrids. Seeds from the various heads were tested for type of starch and each of the two types in the different lots were weighed with the results summarized in Table II.

The point will be raised at once that seeds with normal starchy endosperm may weigh more than those having the waxy endosperm condition even when hybrid vigor is not involved. To determine to what extent the waxy gene normally reduces the weight of the seed the two endosperm types from segregating heads were separated and weighed. Considering the waxy endosperm recessive seeds as 100 per cent, the normal non-waxy seeds were found to have a relative weight of 104.4 per cent. Increases four times this large, however, were found in the crossed seed weights shown above when Hegari and milo were the pollen parents. These results indicate that the increases in size of endosperm were, in part, the effect of hybrid vigor.

It is assumed that the vigor of an F_1 plant is a true indication of its degree of heterozygosity. The F_1 generation grown from the tested seed showed that there was comparatively less genetic difference between Schrock and Blackhul kafir than between Schrock and milo, or Schrock and Hegari. The greater heterozygosity of the Schrock×milo and Schrock×Hegari hybrids shown in the F_1 generation was also in evidence in the size of the F_1 endosperms, as those of Schrock×kafir were smaller than the other two.

Discussion

This study of heterosis in sorghum shows that sorghum varieties differ in their genetic makeup for many genes other than those that are visible in their effect. Milo and Hegari were the two varieties whose hybrids invariably possessed extreme vigor and it is apparent that these two varieties possess a good many dominant genes favorable to growth and production whose recessive allelomorphs are present in such other varieties as kafir, feterita, kaoliang, Sumac, and broomcorn. It is undoubtedly true that the preeminence of milo and Hegari, two of the most important grain sorghum varieties in Texas, and the two varieties grown in Southern California and Arizona under irrigation practically to the exclusion of other varieties, is due to the presence in their genetic makeup of a large number of dominant genes favorable to growth.

The hybrid vigor possessed by hybrids between such other varieties as kafir, feterita, kaoliang, Sumac, and broomcorn, although not as great as that of hybrids having milo or Hegari in their parentage, is great enough, in many instances, to result in grain production double that of their parents. Earliness of maturity is a characteristic of hybrids of this group.

The large increase in production of grain that resulted from crossing Blackhul with Red kafir was accompanied by neither lateness of maturity nor an increase in height. These two varieties possess the same recessive genes for height but a number of different dominant genes that affect growth. It is ap-

parent, therefore, that genes that directly influence height of plant are not by any means the only genes that produce the marked vigor possessed by first generation sorghum hybrids.

In the cases of least hybrid vigor, where hybrids were the offspring of two inbred lines of Blackhul kafir, the increased production resulted largely from a slightly greater tendency for the hybrids to tiller, without any increase in other vegetative characteristics.

It follows that the different degrees of vigor obtained represent differences in the number of dominant genes favorable to growth and that the effect of these genes, although small individually, is cumulative. More specifically, it is apparent that certain genes affect the ability of the plants to tiller, certain others affect the number of nodes, certain others affect size of leaf, etc. Under favorable conditions production should be greatest from the plant possessing the greatest number of dominant genes favorable to growth, but it should be pointed out here that under the climatic conditions existing in the important sorghum-growing regions of the United

TABLE I. Vigor of F_1 Hybrids

	Height of plant, cm.		Stalks per plant		Growing season,	Yield per plant, pounds			
						Forage		Grain	
	Mean	S.D.	Mean	S.D.	days	Mean	S.D.	Mean	S.D.
Vigor of F_1 hybrids in crosses between varieties giving maximum vigor									
Parents:									
Dwarf Yellow milo	142.7	29.6	2.8	.3	105	1.32	.33	.44	.11
Blackhul kafir	125.7	6.7	1.03	.6	105	.64	.26	.20	.04
Hegari	150.1	8.1	2.9	.7	125	1.61	.34	.36	.09
Spur feterita	157.8	7.9	1.3	.5	100	.81	.19	.26	.08
Dwarf broomcorn	109.0	7.1	3.6	.8	105	.79	.17	.20	.05
Hybrids:									
Dwarf Yellow milo x Hegari	246.8	12.2	3.7	.8	136	3.20	.67	.79	.19
Dwarf Yellow milo x Bh. kafir	277.1	15.3	2.8	.8	136	3.05	.73	.69	.18
Bh. kafir x Hegari	315.7	11.1	3.3	.9	153	4.23	.82	.88	.18
Hegari x Spur feterita	296.8	17.9	3.1	.7	153	3.92	.86	.80	.16
Hegari x Dwarf broomcorn	388.6	13.4	4.0	.6	155	4.25	.79	1.01	.24
Vigor of F_1 hybrids in crosses between varieties giving intermediate vigor									
Parents:									
Bh. kafir	125.7	6.7	1.03	.6	105	.64	.26	.20	.04
Spur feterita	157.4	7.9	1.3	.5	100	.81	.19	.26	.08
Sumac	186.8	9.9	2.1	.9	100	1.21	.31	.26	.08
Hybrids:									
Bh. kafir x Spur feterita	188.5	11.6	1.8	.9	97	1.55	.50	.59	.18
Bh. kafir x Sumac	188.3	10.4	1.8	.7	100	1.35	.30	.41	.12
Spur feterita x Sumac	199.1	12.9	2.0	.8	95	1.40	.38	.54	.15
Vigor of F_1 hybrids in crosses between closely related varieties									
Parents:									
Dwarf Yellow milo	142.7	29.6	2.8	.3	105	1.32	.33	.44	.11
Dwarf White milo	135.5	7.8	3.8	1.0	105	1.56	.40	.53	.14
Bh. kafir	125.7	6.7	1.03	.6	105	.64	.26	.20	.04
Red kafir	127.5	8.6	1.03	.6	105	.59	.10	.13	.05
Hybrids:									
Dwarf Yellow milo x Dwarf White milo	140.9	24.7	4.4	.8	105	2.25	.36	.64	.12
Bh. kafir x Red kafir	134.8	21.8	1.7	.8	105	1.12	.36	.43	.16
Vigor of F_1 hybrids in crosses between inbred lines of Blackhul kafir									
Parents:									
Line 153	122.1	8.6	1.1	.4		.74	.17	.18	.06
Line 223	120.3	6.9	1.1	.5		.77	.30	.14	.06
Line 646	115.9	7.2	1.2	.5		.87	.26	.14	.07
Hybrids:									
Line 153 x 223	118.6	5.9	1.6	.8		.94	.12	.19	.09
Line 153 x 646	121.2	6.1	1.5	.9		.86	.33	.20	.08
Line 223 x 646	119.1	8.2	1.4	.6		.93	.33	.16	.08

TABLE II. Effect of Crossing upon Size of Endosperm

	Selfed seed			*Crossed seed*		
Head No.	No.	Av. wt., gms.	Cross	No.	Av. wt., gms.	Per cent increase
1	1313	.0208	Schrock x kafir	849	.0213	2.4
2	573	.0217	Schrock x milo	1159	.0257	18.4
3	1009	.0200	Schrock x Hegari	837	.0237	18.5

States, any variety or hybrid to be suitable for farm use must be homozygous for certain recessive genes that will produce the necessary dwarfness and earliness of maturity.

The results of this study indicate the possibilities that exist for the use of crossed sorghum seed and the practical utilization of hybrid vigor for increasing production, provided a practical method for producing crossed seed in quantity can be worked out. Such possibilities include the method of bulk emasculation of sorghum flowers with hot water, described by Stephens and Quinby,[8] the use of a floral abnormality called "antherless"[6] in which anthers are not produced within the sorghum flower or through the utilization of stock segregating for male sterility such as those which occur so commonly in corn and sugar cane. By planting alternate rows to a desirable pollen parent and weeding out all except the recessive male sterile plants in mother rows all of the seed set on these recessive plants would be crossed seed producing F_1 plants. The male sterile stock could be propagated by cuttings[7] and such mother rows might be perpetuated by establishing semi-permanent ratooning rows in the more southern regions of Texas where sorghums will over-winter rather than depending upon repeatedly isolating the male sterile recessives from seed in segregating stock.

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TWINS WITH TUBERCULOSIS

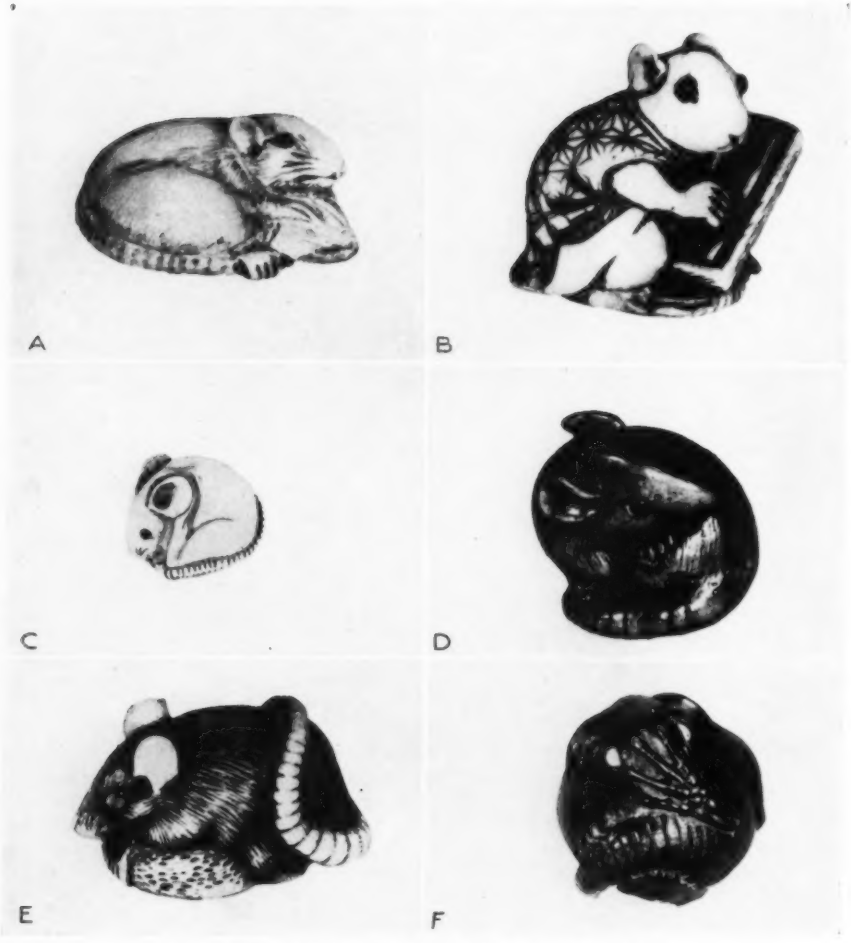
THIS volume* is a sequel to "Zwillingstuberkulose I," published in 1933 by the same authors. The number of twin pairs studied has been increased from 127 to 239. Of the 239 pairs, tubercular changes have been noted in one or both members of 206 pairs. These include 80 identical and 125 fraternal pairs, 44 of the latter being of different sexes. In the identical twins similar intra-pair tubercular tendencies occurred in 80% of the cases, whereas in the fraternal twins such similarities were observed in only 25% of the cases.

A striking contrast is shown by comparing the ratios of concordant to disconcordant pairs in the two types of twins. A concordant pair is one in which both members have had tuberculosis, and both have recovered or have died while affected; whereas in a disconcordant pair only one of the members has had tuberculosis, and has died from the disease. In identical twins the ratio of concordant to disconcordant pairs was 9.1, whereas in fraternal twins the ratio was 1:41.

Of the 170 pages in the book, 114 are given to a description of 185 pairs, 69 identical and 116 fraternal. The case history of each pair is given, as well as X-ray photographs of the lungs. The 185 pairs have been grouped into three classes:

(*Continued on page* 116)

*Diehl, Karl, and O. F. v. Verschuer. *Zwillingstuberkulose II*, 8 chapters, 170 pages, 114 illustrations, 16 tables. Jena, Verlag von Gustav Fischer. 1936.



CARVINGS SHOWING ANCIENT FANCY MICE

Figure 4

Figurines of mice ranging from 70 to 140 years old. For detailed description see text. The fancy mouse was sacred to Daikoku, the god of wealth, and therefore had a considerable vogue. The existence of a large number of mutant types known in modern genetic laboratories is amply proved by some of these interesting figures.

THE ANTIQUITY OF MOUSE VARIATIONS IN THE ORIENT*

CLYDE E. KEELER and S. FUJI
Howe Laboratory, Harvard Medical School

MANY facts point to the antiquity of the mouse fancy in China and Japan, where religious superstition did not interfere with its development as it did in Europe during the Middle Ages.

The fancy probably originated in China. The Eh Yah (lexicon published 1100 B. C.) has a special word for the spotted mouse. One of the poems collected by Confucius (500 B. C.) mentions a dancing mouse, but as it was said to have danced on its hind legs, some poet may have been drawing upon his imagination. The waltzing variety is probably described as early as 80 B. C. in the Annals of the Han Dynasty. This passage was translated by Dean Quentin Pan as follows:

In the ninth moon a yellow mouse was found dancing with its tail in its mouth, in the gateway of the palace of the kingdom of Yen, (now the province of Chili). The animal danced incessantly. The king asked the queen to feed it with wine and meat, but this did not interfere with the performance. The mouse died during the night.

The fact that this mouse was yellow highly suggests that it bore a fancy color variation in addition to the waltzing character.

Origin Probably in China

The Japanese credit China as the original home of the fancy by calling fancy mice "Nankin-Nezumi" or Nanking mice. In 1894 Schlumberger published a note about an ivory netsuké carved by Masateru about the year 1790. This netsuké shows these unit-characters: Pink-eye, piebald, non-agouti (black), albinism and possibly waltzing, if one may diagnose the latter characteristic from the twisted positions of some of the young. In 1935 Tokuda described a rare pamphlet called "Chingan-Sodategusa" or "The Breeding of Curious Varieties of Mice," published in 1787 by Chôbei Zeniya of Kyoto. Three copies of this pamphlet are now known to exist, one of which is in the collection of the junior author. This remarkable publication described the crossing of various types of fancy mice and definitely mentioned the albino, non-agouti, recessive piebald, lilac with pink-eyes and several other varieties which we cannot identify definitely.

In Shanghai and Nanking today the fancy mice are all of the *Mus musculus bactrianus* type and consist of black-and-white spotteds, albinos, pink-eyed blacks, and waltzers. In Peiping, in addition to these types which are probably purebred bactrianus, there are mice of larger size which undoubtedly bear some *Mus musculus* blood from Europe.

In Japan both musculus and bactrianus are to be found. A chocolate musculus female was located in a Nagoya pet shop. She was nursing a litter of young in which pink-eye dilution was segregating. In Tokyo a blue dilute bactrianus specimen was procured. In Japanese medical schools, American albinos are now frequently employed and they are beginning to filter into the fancy.

Fancy Mice in Art

A number of art objects in the collection of the junior author further testify to the antiquity of certain variations in oriental fancy mice. In this collection there are colored prints showing albino mice and rats and one of particular in-

*Part of these observations were made possible by a grant to the senior author from the Milton Fund of Harvard University.

DAIKOKU'S PETS

Figure 5

A. Terra cotta figurine, 21 centimeters high, of a baby holding a black and white piebald mouse by the tail. Note the characteristic position of the head of the mouse. The figure was made at Kyoto about a century and a half ago. *B*. Terra cotta figures used in a game of "mouse chess," in which the god of wealth, Daikoku (the squat figure at the left), attempts to capture his fancy mice, whose moves are controlled on a board. Usually sixteen mice were used, though only five remain in this set.

terest depicting a wedding of mice dressed in Japanese costume. In this print the artist was careful to represent albinos (white with pink eyes), pink-eyed dilutes (light brown tinged with orange and having pink eyes) as well as grays.

The accompanying figures are from photographs of carvings and clay images mostly from this collection which bear hereditary mouse variations. All photographs show the objects in natural size save that in Figure 5*A*.

Figure 4*A* shows an ivory netsuké representing an albino mouse (with pink eyes), eating the kernel of a chestnut. It is about 70 to 80 years old.

Figure 4*B* shows a black-eyed-white anthropomorphic mouse with an abacus "soroban." It is of ivory and from 70 to 80 years old.

In Figure 4*C* is depicted an Ojime or bead, carved from ivory by Isshu about 80 years ago. It is an albino with pink eyes.

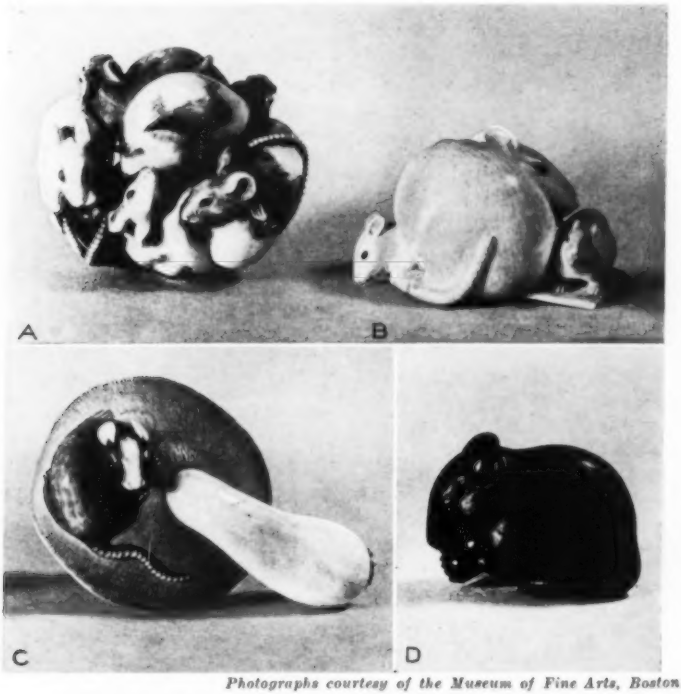
A box-wood Tsuge netsuké made about 80 years ago is shown in Figure 4*D*. It represents a black-eyed-brown mouse.

In Figure 4*E* is represented an ivory netsuké with amber colored eyes. It is from 120 to 130 years old and was probably intended for a pink-eyed dilute gray because the scratches representing the hair are filled with black stain.

Figure 4*F* represents a netsuké of exquisite workmanship. It is about 130 to 140 years old. It was carved from box-wood and bears eyes of pink coral. Quite possibly it is the work of Masanao the elder. The color of this netsuké may be intended to represent the chocolate pigment variation in addition to the pink-eyed-dilute character.

A painted terra cotta figurine (21 cm. high) of the type known as "Fusiminingyo" is represented in Figure 5*A*. It was made in Kyoto about 150 years ago. A fat baby boy holds a black-and-white piebald mouse by the tail. The head of the mouse is held in the unique position assumed by waltzers and shakers.

Figure 5*B* represents terra cotta pawns in a game known as "jurokumusasi" in



Photographs courtesy of the Museum of Fine Arts, Boston

NINETEENTH CENTURY JAPANESE FANCY MICE

Figure 6

For descriptions of these carvings see text. In them are shown unspotted, black-eyed white, and recessive piebald mice (*A*), a pink-eyed albino with black-eyed white offspring (*B*), a white-faced piebald (*C*), and a jet-black mouse (*D*). These carvings from the early nineteenth century show that many variations of the fancy mouse existed in Japan a hundred years ago. Its beginnings trace to China many centuries earlier,—a reference from the Han dynasty (80 B. C.) suggests that yellow waltzing mice existed at that remote time.

which Daikoku (the god of wealth), controlled by one player, tries by certain moves to corner 16 fancy mice which are moved by a competitor. A board bearing special lines is employed in the game. The five mice here shown are now brown piebalds with black eyes, but it is probable that the color has faded from black piebald. They and the Daikoku are about 200 years old and may have been made in China.

A survey of Japanese carvings in the Museum of Fine Arts at Boston reveals additional objects worth adding to this list.

Figure 6*A* represents a nineteenth century ivory carving by Mitsushika. In the group are unspotted, black-eyed whites and recessive piebald varieties.

Figure 6*B* depicts a nineteenth century carving by Rantei showing an albino mother (with pink eyes) washing one of her two black-eyed white young. All three mice are on an open book.

In Figure 6*C* is shown Masakazu's ivory carving of a mouse on the underside of a mushroom. This is from the early nineteenth century. This mouse is of particular interest because it is the only carving that we have come upon which shows the white-face expression of spotting factors. Such markings

could be produced by two genes for recessive piebald selected for pigmentation, one gene for recessive piebald selected for white or one gene for dominant (lethal) spotting with certain modifiers.

Figure 6*D* shows a persimmon wood carving by Okatomo from the latter part of the eighteenth century or the early part of the nineteenth. The mouse is jet black and bears black eyes.

Thus, the art objects here described add further evidence as to the antiquity of the mouse fancy in the orient and to the popularity of the fancy varieties as art subjects. The objects here described represent the hereditary variations: albino, pink-eyed dilute, chocolate, black-eyed white, recessive piebald, black, white face, and possibly waltzer.

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THE GENETICS CONGRESS

SINCE our last issue no further word has been received regarding plans for the Seventh Genetics Congress. The only developments to report are of an indirect nature, regarding the general status of genetics in the Soviet Union. These throw some light on the reasons for postponing the Congress, and may help to an understanding by geneticists of other countries of the situation in the Soviet Union.

Two dispatches published in *Nature* (London) throw some light on the Congress prospects—or lack of prospects. These appeared in the issues for January 30 and February 6, 1937. The information they contain and the viewpoints which they represent will interest many American geneticists:

Genetic Theory and Practice in the U.S.S.R.

A report of the fourth session of the Lenin Academy of Agricultural Sciences, which was held in Moscow in December last, has been received from the Soviet Union Year Book Press Service, 623-4 Grand Buildings, Trafalgar Square, London. Apart from seventy-one special papers, there was a general debate on the present position of research in genetics. This apparently took the form of an attack on modern genetic theory by experts who have been engaged in the study of practical problems unrelated to genetics. The grounds of the attack were ostensibly twofold. First, geneticists like Muller and Vavilov were said to have neglected the Marxian principle of the unity of theory and practice in failing to keep their work in touch with the needs of farmers. Secondly, the primary assumptions of genetics were held to be invalid. Presumably, in the absence of other evidence, the second contention was deduced from the first. The attack was reinforced by pointing to work like that of Michurin and Lysenko which, unhampered by academic prejudice, has yielded results of immense practical value by methods of trial and error.

Michurin is described as a "self-made practical plant breeder"; his published work has unfortunately not been translated into any foreign language. He is understood, however, to have made hybrids and discovered sports in various economic plants of a kind never produced elsewhere. Lysenko, on the other hand, is well known as the author of the technique of vernalization, which he invented apparently without knowledge of the previous experiments conducted abroad on the same subject. This worker went further than the other disputants and promised that the physiological behaviour acquired by plants under his treatment could be inherited, winter wheat being turned into spring wheat and *vice versa*. If this were true, the tedious methods of plant breeding now practiced by orthodox geneticists in Prof. Vavilov's institutions would of course be superfluous.

The situation revealed by this discussion is astonishing in more than one respect. It is a commonplace and as old as Aristotle for scientific men unfamiliar with experimental methods to set forth Lamarckian doctrines in explaining evolution. For experimental workers to set out a Lamarckian method for the advancement of practical breeding is, however, something new and particularly remarkable in the Soviet Union, where the moral bias of this ancient myth might well have made it suspect. Still more astonishing is it to find that these arguments are combined with a charge of doctrinal incompetence against Muller and Vavilov, who, while making fundamental contributions to genetic theory, have probably done more than any other living workers in this field to show its practical value to mankind.—*Nature*, Jan. 30, 1937.

Science in the U.S.S.R.

References were made in *Nature* of January 23 (p. 142), and January 30 (p. 185) to the position with regard to the International Congress of Genetics which was to have been held

in Moscow this summer. A request for further information was sent to His Excellency the Russian Ambassador, who has favoured us with a statement on the recent meetings of the Lenin Agricultural Academy (see *Nature*, Jan. 30) and on the International Congress of Genetics. Dealing with the latter, the statement is as follows:

"As to the postponement of the Genetics Congress, it is a fact that this was due to requests received by the organizers of the Congress from a number of scientists who wished to have more time for preparation for it. The sole motive for such a postponement was therefore the desire to secure the very best preparation for the Congress and the widest possible participation in its work by scientists of different countries. One thing must be borne in mind in any discussion of the problems of scientific development in the U.S.S.R. The U.S.S.R. is a country of planning. The whole economy of the country, and also the various branches of its cultural and scientific activities are regulated by a definite State plan. Science is planned, not, of course, in the sense that every minute detail of scientific research, etc., is laid down beforehand in a Government Department. That would be ridiculous. But science is planned in the sense that the broad outlines of its development are brought into line with the most urgent requirements of practical life. The prevailing view in the U.S.S.R. is that science must not consider itself a demigod with the right to choose its own course without any reference to the needs and requirements of the people. On the contrary, the primary object of science is to serve as faithfully as possible the needs of the people, and, indeed, of humanity. Some scientists in foreign countries seem to be inclined to confuse the planning of science, in the above sense, with a lack of scientific freedom. But this is a cardinal error. The planning of science, like planned economy, prevents the waste of human energy and endeavour, and makes it possible to concentrate the greater part of scientific effort on the points of real need of the people and of humanity. The great advantages of such a system are clearly shown by the enormous advance of science in the U.S.S.R. during post-revolutionary years. Indeed, every unbiased observer will testify to the very great prospects for scientific development which exist in the U.S.S.R., such as can be found in scarcely any other country."—*Nature*, Feb. 6, 1937.

The statement by the Soviet Ambassador in London is most interesting in connection with the general problem of science in a "country of planning." It is readily conceded that within limits planning of research is highly desirable. Many sciences have reached a point of such complexity that no single individual is in position to make significant advances, and a group attack necessarily implies planning and cooperation of some sort. At the last Genetics Congress, Professor T. H. Morgan, challenged to outline the next steps in Genetics, listed five important genetic research "fronts" as appealing to him as being of most promise (". . . although I realize only too well that my own selection may only serve to show to future generations how blind we are [or I have been, at least] to the significant events of our own time.") Professor Morgan then admitted his inability to "plan" those advances which he placed first in importance in the following words:

"Should you ask me how these discoveries are to be made, I should become vague and resort to generalities. I should then say: By industry, trusting to luck for new openings. By the intelligent use of working hypotheses (by this I mean a readiness to reject any such hypotheses unless critical evidence can be found for their support). By a search for favorable material, which is often more important than plodding along the well-trodden path hoping that something a little different may be found. And lastly by not holding genetic congresses too often."

The diplomat's confidence that scientific progress will be expedited by "practical plans" is not echoed by the research worker! So often has "obviously impractical" research produced revolutionary practical results that the planners may well need the luck Morgan cites to keep on the forefront of genetic progress. When we add the "political" complications of heading off inspirational "border raids" like that evidently staged by Lysenko and the followers of Michurin, the difficulties of Soviet genetic planning seem very formidable indeed.

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THE TERM "GENETICS" SHOULD BE DISCONTINUED

AN amusing by-product of the Genetics controversy in Russia is contained in the following remarkable letter of the *New York Times* under date of December 21, 1936:

The schism among Soviet geneticists which

led to the cancellation of the genetics conference grew in part out of a theory of inheritance which I printed privately in 1933. Several copies were sent to Russia. Professor Lysanko's attacks on the "classical geneticists" are well based. Mendelism is a statistical statement of the distribution of seeds in the protein-synthesis and disperse-enzyme (amino-acid) stages of metabolic development. The ratios are determined by activity of enzymes and vary widely with metabolism.

Chromosomes are transitory, intermediate products like starch grains, determined in degree of development by intensity in metabolism. The diploid number is only that of the intermediate range of intensity of catalysis. Hyper-intensity of catalysis may cause polyploids. Weak metabolism near the extinction value generates some triploids, and irregular and broken chromosomes. Distortion or destruction of chromosomes, attributed to direct action of toxics, irradiation, etc., is in fact largely a continued consequence of distortion of metabolic processes in the generating nucleoplasm.

All phenomena of heredity are dynamically developed. The hypothesis of unit characters, factors, genes, is superfluous. There is no independent science of genetics, which is merely the special physiology of inheritance. Physiology is the sole basic science of plant life and modification. All other sciences of plant life are derivative. The use of the word "genetics" should be discontinued.

V. A. Clark

Brooklyn, Dec. 17, 1936

It is discouraging, just as we are entering an era of great genetic progress, to learn that the whole subject is actually non-existant and that even the name should be wiped off the pages of the dictionaries!

GROWTH WITHOUT CHROMOSOMES

IT has long been recognized that development represents a complex interacting of forces within the cell. No little ink has been spilled in discussions attempting to evaluate the relative influences on development of the protoplasm inside the nucelus and of that in the remainder of the cell (cytoplasm). It has proved difficult to settle the matter experimentally, though several hopeful approaches have been made. This lack of conclusive experimental evidence has been a fertile source of speculation and of continuing controversy of no little interest to geneticists.

The experiments of the greatest genetic interest have been those concerned with the effects on development of increasing or decreasing the "concentration" of chromosomes in the nucleus. Complete extra chromosomes produced the trisomics of Blakeslee. Several haploid plants, and just very recently a haploid animal (in addition to bees, wasps and aphids), have been reported and illustrated in the Journal. In the presence of all these varying chromosomal "concentrations," fairly normal development has been possible as long as at least *one complete set* of chromosomes is present.

Recently this technique of chromosomal tinkering has been carried to a very illuminating *reducio ad absurdum* (that term being used in a very complimentary sense) in experiments on egg fragments from which all the chromosomes are removed. By centrifuging the eggs of the sea urchin (*Arbacia punctulata*) Dr. Ethel Browne Harvey (*Biol. Bull.* LXXI: 101-121) was able to cause them to divide in such a way that one "half" of the egg contains the nucleus and all the pigment, and the other "half" contains most of the cytoplasm. A given batch of eggs responds very uniformly to the centrifuging treatment, so that large quantities of "halves" containing no nucleus can be obtained. These nonnuclear fractions if exposed to parthenogenetic agents (such as concentrated sea water) undergo cleavage, and development slowly continues through the blastula stage. "An egg fragment lacking both maternal and paternal chromosomes

has given rise by repeated cleavages to an embryo containing about 500 cells with a certain amount of differentiation. An embryo arising from a non-nuclear egg has lived a month; it is probable but not certain that these have cilia and are free-swimming. The early stages of development can, therefore, take place without chromosomes. This means that the maternal cytoplasm is of great importance and has within itself the potentialities of determining at least the early stages of development."

This early development of an egg entirely lacking chromosomes may be due either to elements secreted by the nucleus before its elimination by centrifuging or to the innate structure of the egg cytoplasm. The non-nucleate egg fragments develop much more slowly than the normal eggs and than the fragments containing the nucleus. For development to be initiated certain granules seem to be essential, suggesting possibly that the nucleus and the chromosomes contain specialized enzymic and catalytic controllers of development which occur in a more generalized form in the cytoplasm. These specialized chromosomal "architects of development" seem necessary after growth has passed beyond the first simplest stages. The concept that development is controlled by the interaction between the genic and cytoplasmic constituents of the cell, further interacting with a variety of elements in the extra-cellular environment, seems to be strengthened by these studies. Geneticists need hardly be disconcerted by this rather striking demonstration that the chromosomes perhaps represent specialized "organs" to control the "developmental urge" of undifferentiated protoplasm, which of itself is adequate to elaborate the basic groundwork of embryonic development.

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EUGENICAL STERILIZATION

THIS book is a fairer statement of the problem than the reviewer would have expected, for several reasons. The chairman of the committee has stated in the introduction to his book on "Inheritance of Mental Disease" that he "shall endeavor to make a case for this belief" (namely that the race is injured by adverse environmental conditions whose effect may last three or more generations and then die out, and that transmissible mental diseases are therefore not hereditary) "though confessedly drawing in some part upon my hopes as well as upon facts." A second reason is that the reviewer is a little skeptical of investigations conducted by those who may be prejudiced either for or against a cause, and who have not the requisite training in the sciences upon which the evidence centering around the question is based. The average physician has neither the genetical nor the statistical training to evaluate properly evidence that is based on genetics or statistics. This skepticism was enhanced a few years ago by the statement of a prominent neurologist who with several of his confrères was investigating the clinical, therapeutic and pathological aspects of a well known neurological condition. It was suggested to the chairman of the commission that the hereditary aspects of the disease be also studied. The answer was that that aspect was also being well looked after; they were having the laboratory technician handle that part of the problem. Perhaps it was due to

*Eugenical Sterilization: A Reorientation of the Problem. By the Committee of the American Neurological Association for the Investigation of Eugenical Sterilization. A. Myerson, J. B. Ayer, T. J. Putnam, C. E. Keeler and L. Alexander. The Macmillan Co., New York. 211 pages, with 20 pages of references. Price $3.00.

the inclusion of a geneticist on the present commission to investigate sterilization that the statement of the problem is a fairly accurate one.

The book takes up briefly the laws which have been passed in the United States and elsewhere regarding sterilization; the main arguments for it; other points of view with respect to it; the relation of genetics to eugenics; the studies which have been made on the inheritance of mental disease, especially dementia praecox, manic-depressive psychosis, feeble-mindedness and epilepsy; the chronic progressive neurological diseases; the relation of crime and genius to sterilization; the importance of twins in genetic investigation and finally the recommendations of the committee.

In reviewing the laws, attention is called to the operation of the California law, where most of the sterilizations have been performed. It is stated that "class discrimination" exists in this law, because the patients cared for at home or in private institutions are exempt from the law, so that social and financial status also plays a role. In the recommendations at the end of the book, it is stated that laws should be applicable to those in private institutions as well as those at large, with which the reviewer fully agrees; but it must be remembered that in the beginning, when sterilization laws were first passed, as indeed, at the present, the appeal to the altruistic motive of bettering the race a hundred years from now fell on deaf ears except among the very few who see more than the immediate present. Appeal had to be made on the basis of the pocketbook of the tax-payer, and those in private institutions or those cared for at home naturally did not increase the pinch of the economic shoe, and hence were not included in the law.

It is rather amusing to a person who is not "sold on" the present day psychiatric and psychologic explanations in their entirety, to read that "it is curious to note that it is this state (Kansas) which has remained dry since the repeal of the prohibition enactment, which rather sadistically, perhaps, practices asexualization." Apparently the committee feels that it is evidence of a much higher level of intelligence and emotional stability to get gloriously drunk than to remain sober; and that if one has not moral stamina enough to get drunk, one takes out one's deficiencies by preventing feebleminded persons from perpetrating sex offences.

In the section dealing with the main arguments for sterilization, it is pointed out that the so-called necessity for sterilization is the alleged tremendous increase in the percentage of mental cases. Data are brought forward to show that the mentally ill person does not usually marry and that those who do marry do not reproduce to the same extent as do normal persons; therefore there is no sudden biologic need for precipitate action. Also, that the apparent increase in mental illness is due largely to the increased facilities for caring for the mentally ill in hospitals, and that most of the increase is in admission rate, not in actual increase in proportion to the population. The death rate of the mentally ill also is higher than in the normal population, so that the expectation of life is materially reduced. In Massachusetts, the life expectation of males in general at the age of two years is 56.8 years. For idiots this is reduced to 20 years, for imbeciles to 29.6 years, and for morons to 52.2 years. The same relative expectations of life are found for females.

The reviewer would like to point out, even granting the accuracy of these data, that in idiots and imbeciles the mental defect is so bad that not only is procreation handicapped by the higher death rate but also by the fact that they are usually institutionalized, and because of the very severity of their defect they are not selected for marriage. This is also the group which shows the least evidence of *direct* heredity, coming as they so often do, from normal parents. But the morons, whose life expectation is practically that of the normal person, are, in the higher grades at least, not institutionalized; they do find mates among their own intellectual level, or a little

higher; and it is in this group that fecundity is most marked. The mentally ill, and those with gross mental defects are not the ones for whom sterilization is most desired. It is for that group which is not bad enough to be in an institution, which is not good enough to look after its own offspring, which does not have a high enough intellectual level to do anything other than the lowest grade of unskilled labor—of which in our modern civilization there is progressively less and less—that sterilization would be decidedly worth while. The statement of the committee that we need morons of higher character to do the menial and low grade tasks of the world must be taken cautiously, as modern civilization is constantly eliminating this type of labor. We agree with the committee that committing the mental defectives and the mentally ill to institutions is expensive but is better than leaving them at large in the community and hence such large expenditures for their maintenance is an eugenic measure; at least we agree so far as those are concerned who are a danger to themselves and the community in other ways than in their ability to procreate. For the number who can look after themselves, but not after a family (whose chief danger is an eugenic one) we feel that there is a better solution than building institutions to house them at public expense. If when the need for the institutions was lessened or non-existent, they could be scrapped, the expense might be justified; but they become a vested interest whose continuance is demanded by the army of employees who have been hired to take care of the defectives and by the politicians whose office-holding depends upon votes of these employees and their families.

I would point out several arguments which I believe to be fallacious. In discussing dementia praecox, they mention Rüdin's work, and exclaim over some of his findings that "it would seem to be eugenically better to have a schizophrenic or alcoholic parent, than to have two healthy parents and some remote collateral occurrence of schizophrenia." Astonishing as they seem to find this result, I would recall that in the case of hemophilia, which has been designated the "most hereditary of hereditary diseases" (although with this I do not agree since many others are *just* as hereditary) it is infinitely safer for a lad to have a father with hemophilia than to have a maternal uncle, or indeed any male relative of his female ascendants with hemophilia. Sometimes a collateral history of the disease *is* worse than a direct history of it.

In the chapter on genius and eugenics, a long list of distinguished persons whose family history indicated some mental illness is given; and it is stated that had sterilization been carried out in the past, many whose worth to civilization is greater than "the cost of maintenance of all State institutions put together" would never have been born. Then follows a list of persons who might never have been born had sterilization laws been extant a century or more ago. With this I cannot agree. First, since most of these persons had a history of manic depressive psychoses in their families, and since many of these psychoses may not have occurred until after their children were born, sterilization of the mentally affected person would not necessarily have cut off the birth of these brilliant persons. Second, in some cases, the mental illness was not even in a parent but appeared in a sister or brother. Just how the committee can justify the statement that sterilization of Diderot's sister would have prevented Diderot's birth, and so have lost this particular genius to posterity, or how Goethe's sister having manic-depressive psychosis and being sterilized would have lost to the world the *Sorrows of Werther,* is hard to see.

Ascendants are said to have been alcoholic. As most of the persons in those days were alcoholic, would sterilization have been proposed for a trait which most persons showed and which most regarded as normal? Dostoievski, so the list states, suffered from epilepsy and his son had epileptic seizures. Who would have been sterilized in this case to have prevented Dostoievski's birth,

who, by the way was the genius, and not his son?

Finally the inclusion of Napoleon, whose dreams of world power have left their legacy of hate throughout Europe, with war after war to pay off old scores, seems to me to be rather far fetched, especially when we are asked to believe that he was worth more than all the cost of all the insane to all governments. Moericke, another "genius" on the list whose contribution to the world is supposed to be worth more than the cost of all the insane, is not even included in the *Encyclopedia Brittanica* 14th edition. And his failure to appear on the scene due to the supposed ruthlessness of the sterilization laws of several generations ago, was to be due to the fact that one brother was querulent, and another a ne'er-do-well. As was pointed out even the most ardent of eugenic propagandists have not gone the lengths of sterilizing brothers and sisters in order to prevent their mother from having children; and who has advocated sterilization for being "querulent"?

I do not for a moment doubt that many excellent minds have been found in a stock which also held some mental illness, especially of the manic-depressive type. But why not be fair, and accurate? Why not make a systematic survey of the percentage of brilliant persons who come from parents who were not sufficiently mentally ill to be institutionalized, and what percentage comes from those parents who are thus severely ill? Do those of high intelligence come from institutionalized patients in greater percentage than such patients exist in the population? If they do not, then one might well question whether even those geniuses who come from such mentally ill stock could not be dispensed with. Until some such study is made, a list of persons who have written verse or made war and whose relatives have been outspokenly ill mentally, or even eccentric is worse than useless. Surely the committee must see, from its own reasoning, that such a list has no more value than would a list of criminals whose relatives have been mentally ill.

Finally there emerges a set of recommendations with which for the most part I am heartily in agreement. I would recommend certain modifications of the list of diseases in which sterilization is justified. Why limit sterilization to those mothers who have *more than one* affected child? The committee advises sterilization when "familial" Friedreich's ataxia or "familial" feeblemindedness occurs. Now the term "familial" as used in medical literature is applied only to cases where two or more children are affected. If only one is affected, it is a "sporadic" case. Since we know that Friedreich's ataxia may appear in a second child, once it has shown itself in one, why compel the mother to produce two of the defectives before we are convinced that she should be spared having any more? Even Mongoloid imbecility, which appears more often in only one than in more than one in the family, occurs with sufficient frequency in a second child to justify the mother's request to be spared having another.

The committee recognizes that there is a sociologic reason for recommending sterilization of the feebleminded even when the defect is of environmental origin, as a feebleminded parent would have difficulty in assuming the burden of a family. There is an even stronger reason. No normal child should be forced to be raised in a family where one or both parents are feebleminded, even if their mental defect were of environmental causation. For the same reason, I feel that the committee makes a mistake when not urging sterilization of the epileptic, even though the epilepsy is not hereditary. We have too long considered the rights of the parents to reproduce; it is time that we began to consider the rights of children not to be born into families whose heritage or whose environment is so conditioned that the child cannot expect from the parents that love, that sense of security and understanding which according to the psychiatrists is essential for the normal mental development of the child, and which according to all of us, is his inalienable right.

MADGE THURLOW MACKLIN
University of Western Ontario

ALBINISM IN A COCKER SPANIEL

JAMES McI. PHILLIPS
Galloway, Ohio

A NEAR-ALBINO SPANIEL
Figure 7

The absence of any spots in this puppy indicates that his white coat and blue eyes are due to a gene for partial albinism, rather than to an extreme expression of the white piebald spotting gene.

THE most notable example of albinism in dogs—uncommon in any breed—is a strain of Pekinese reported in 1929 by Pearson, Nettleship, and Usher.[5]

The Cocker Spaniel King Cotton, bred by Mr. John C. McLaughlin of Washington, D. C., seems to be an example of partial albinism similar to that found in some of these Pekinese. In thirty-seven years' experience breeding Cockers, we have heard of no other case of albinism.

Cockers may be self black, liver or chocolate, or the various shades of red and yellow ranging from mahogany red through light reds, oranges, and buffs to light creams.[6] Any of these reds or yellows may have either black or brown noses or footpads. In addition to these solid colors there are three types of particolors. The first is due to a recessive

pattern factor which may convert blacks or livers into black and tan, or liver and tan, bicolors. The second is due to a multiple factored recessive white splashing which may convert any solid color into a piebald. The third type is a combination of the other two producing tricolors. Particolors due to dominant white spotting such as is found in harlequin Danes[3] or to the merling which is seen in Collies[4], Daschunds, Dunkerhunds[2], and Trigg strain Foxhounds, are unknown. There is also a recessive dilution factor occasionally found in Cockers which converts blacks into blues, livers into a sort of silver fawn, reds into light reds and creams, and light yellows or creams into what appear to be pure whites. These dilute whites have dark noses and footpads while their eyes show the same variations in color that are found in undiluted specimens. One of these dilution creams was described by us in 1915.[1] Dilute livers and blacks have very brittle hair so that they usually look like mangy specimens with bare patches of skin visible by the time they are six months old, while dilute reds may have fair coats. No other variety of white has been reported in the Cocker.

Extreme development of the recessive piebald spotting is responsible for white dogs in several breeds such as white Collies. These dogs occasionally have one or both eyes blue—called "china" or "glass" eyes. Their noses may be mottled or "butterfly" but they can be distinguished from the partial albinos by the fact that the colored areas of the skin, nose, and footpads are of normal intensity and they never show ghost patterns in the coat. Similarly many breeders have tried for brief periods to produce white Cockers by intensive selection from the particolor stock, but we have never heard of a single all white specimen being thus produced. All have had full colored spots on the tips of one or both ears. If these efforts were more persistent they would probably be successful.

Both the father and the mother of King Cotton were red and white particolors. The litter consisted of six males, all red and whites except King Cotton. This puppy at the age of six months is, to the naked eye, pure white without a trace of color anywhere in the hair. His eyes, which, unlike the albinotic Pekinese, show no photophobia and which show no deformities, are blue. His hearing is good. His nose and footpads and some flecks in the skin around the nose and lips show a very light brown pigmentation. What may be a slight ghost pattern shows in photographs. His nails are colorless or very light. It will be noted that this dog differs from other whites in the particulars just mentioned, and would therefore seem to belong to the albino series.

If this puppy reaches maturity we hope to make breeding tests to determine his genetic makeup.

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A possibly confusing typographical error occurred in Dr. H. H. McKinney's article on Viruses, February issue, Page 52, 18-19th line from bottom left-hand column: *precipates* should read *precipitates.*

NON-RANDOM CROSSING-OVER IN NEUROSPORA

CARL C. LINDEGREN and GERTRUDE LINDEGREN*

Dept. of Bacteriology, University of Southern California, Los Angeles

IN the long narrow ascus of *Neurospora crassa*, eight haploid spores are laid down in a row as a direct result of the reduction divisions. First- and second-division segregations can be distinguished[7] and it has been shown that the spindle-fiber attachment does not split at the first reduction division.† Therefore, it is possible to use the spindle-fiber attachment (*sfa.*) as a locus. In addition, two other loci on each side of *sfa.* were mapped and preparations made for a critical study of crossing-over in these four regions. Previous experiments showed that there was a preponderance of 2-strand double exchanges, and the present study has added to this excess sufficiently to warrant the interpretation of these data in the form of a new theory of crossing-over.

Experimental

The progeny of 422 hybrid asci heterozygous for the factors differentiating *sex*, *gap*, *crisp*, and *pale* (Lindegren[8]) were grown and analyzed. The parental forms were (+), *gap*, *non-crisp*, *pale*, [+ *GP*], and (—), *non-gap*, *crisp*, *non-pale*, [—*C*]. The *sfa* is located between *gap* and *crisp* as shown in Figure 8. Region I (+ to *G*) is 4.8 morgans long; region II (*G* to *sfa*) is 3.6 morgans long; region III (*sfa* to *C*) is 3.8 morgans and region IV (*C* to *P*) is 9.7 morgans long.

Table I shows the arrangements of the different genotypes in the asci and the interpretation of the crossing-over which had occurred to produce these genotypes in their particular arrangements. End to end arrangement in the ascus is not indicated. In one group (+*GP* +*GP* —*C* —*C*) there was a sufficient number of asci to determine that the end to end orientations were at random. In 143 asci the arrangement was +*GP* +*GP* —*C* —*C* and in 147 the arrangement was —*C* —*C* +*GP* +*GP*. These are the asci in which no detectable exchange occurred in the four regions under observation. The random arrangement in the ascus proves that when the tetrad on the equatorial plate of the first meiotic spindle separates to form two dyads:

$$\frac{+\ G\ .\ c\ P}{+\ G\ .\ c\ P} \quad \text{and} \quad \frac{-\ g\ .\ C\ p}{-\ g\ .\ C\ p}$$

these dyads are carried to the two opposite poles purely by chance. This supports the view that the dyads on the second meiotic spindle are oriented and separated at random. Therefore, when a crossover has occurred in region IV so that one dyad has the composition, $\frac{+\ G\ .\ c\ P}{+\ G\ .\ c\ p}$, the +*GP* chromatid will be separated from the +*G* chromatid in a purely random manner. Data on the arrangement of spores in the ascus after crossing-over between *sfa* and (+) confirm this view. Asci in which the four genotypes are arranged

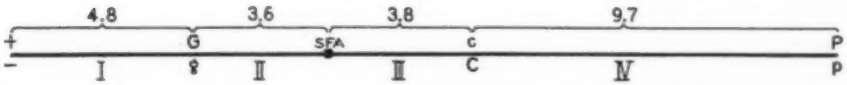
*The writers wish to express their indebtedness to Miss Mary Allan Scott for her generous cooperation in making the diagrams.

†The reader is referred to Dr. Lindegren's earlier paper in the JOURNAL (July 1936) for a detailed discussion of the reproductive cycle in Neurospora. The fungi have considerable value for genetic research because in the haploid phase of the reproductive cycle (alternation of generations) the complication of dominance does not enter in, and direct readings can be made of all known genes—whether dominant or recessive.—EDITOR.

TABLE I—Spore Arrangements and Interpretation of the Exchanges Causing Them in 422 Hybrid Asci

			SPORE ARRANGEMENTS				NUMBER OF ASCI			FREQUENCY OF EXCHANGE				FREQUENCY of DOUBLE EXCHANGE															
														TWO-STRAND				THREE-STRAND							FOUR-STRAND					
			1-2	3-4	5-6	7-8	Complete	Incomp.	Total	I	II	III	IV																
NON-CROSSOVERS			+GP	+GP	-C	-C	273	17	290																				
SINGLE EXCHANGES		I	+GP	-GP	-C	+C	6	1	7	7																			
		II	+GP	-P	-C	+GC	18	1	19		19																		
		III	+GP	+GC	-C	-P	16		16			16																	
		IV	+GP	+G	-C	-CP	48	4	52				52																
DOUBLE EXCHANGES	TWO STRAND	I II	+GP	+P	-C	-GC																							
		I III	+GP	-GC	-C	+P																							
		I IV	+GP	-G	-C	+CP	10	*	10	10			10			10													
		II III	+GP	-C	-C	+GP	2		2		2	2				2													
		II IV	+GP	-	-C	+GCP																							
		III IV	+GP	+GCP	-C																								
	THREE STRAND	I II	+GP	-P	+C	-GC																							
		I II	-GP	+P	-C	+GC																							
		I III	-GC	+GC	-C	+P	1		1	1		1																	
		I III	+GP	-GC	+C	-P	1		1	1		1							2										
		I IV	+GP	-G	-CP	+C	5	2*	7	7			7																
		I IV	-GP	+G	-C	+CP	1	1*	2	2			2						6										
		III III	+GP	-C	+GC	-P																							
		II III	+GP	-C	+GC	-P																							
		II IV	+G	-P	-C	+GCP																							
		II IV	+GP	-	+GC	-CP																							
		III IV	+G	+GCP	-C	-P																							
		III IV	+GP	+GC	-	-CP																							
	FOUR STRAND	I II	-GP	-P	+C	+GC																							
		I III	-GP	+GC	+C	-P																							
		I IV	-GP	+G	-CP	+C	3		3	3			3													3			
		II III	+GC	-P	+GC	-P	1		1		1	1															1		
		II IV	+G	-P	+GC	-CP																							
		III IV	+G	+GC	-CP	-P																							
TRIPLE EXCHANGES	2st + 2st	I II III	+GP	+C	-GP	-C	2		2	2	2	2		2		2													
	3st + 2st	I II III	+GP	-C	-GP	+C	1		1	1	1	1				1		1											
	3st + 4st	I III IV	+G	GC	-P	+CP	2		2	2		2	2						2										2
	4st + 4st	I III IV	+GC	+CP	-G	-P	1		1	1		1	1			1										1			1
	2st + 2st	II III IV	+GP	-CP	-C	+G	1		1		1	1	1			1	1												
	2st + 3st	II III IV	+GP	-C	+G	-CP	1		1		1	1	1			1					1								
QUAD. EXCHS.	2st + 2st + 3st	I II III IV	+GP	+C	-CP	-G	2		2	2	2	2	2	2		2					2								
	2st + 2st + 2st	I II III IV	+GP	+CP	-C	-G	1		1	1	1	1	1	1		1	1												
									422	40	30	32	82	4	1	10	8	2	1	4	6		3		1	3	1		3

*Asterisks indicate double exchanges which could have been either two-strand or three-strand.



LOCATION OF MARKER-GENES ON THE SEX CHROMOSOME

Figure 8

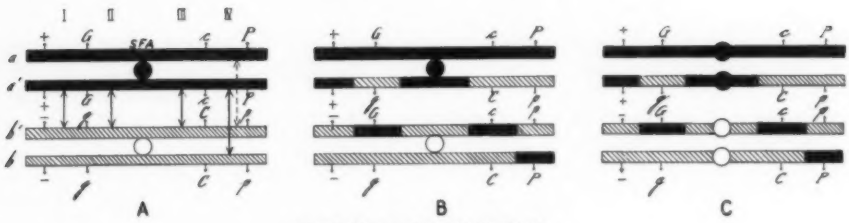
Map of the sex chromosome of *Neurospora crassa* with loci and regions near the spindle fiber attachment (*sfa*) indicated. The method of locating these genes, and the great value of this species for genetic studies were the subject of a recent article in this JOURNAL (July, 1936; 27:251-259). The reader is referred to this article for these details.

serially from one end in the following manners:

+GP	+G	—C	—CP
+GP	+G	—CP	—C
+G	+GP	—C	—CP
+G	+GP	—CP	—C
—C	—CP	+GP	+G
—CP	—C	+GP	+G
—C	—CP	+G	+GP
—CP	—C	+G	+GP

all are listed in Table I as *+GP +G —C —CP*. This simplification of the data has been followed in each case in Table I. To demonstrate the technique of analyzing the crossing-over which has occurred in a tetrad, one of the quadruple exchanges (*+GP +C —CP —G*) is shown in Figure 9. In 9*A*, the synapsing chromosomes and the five loci involved, are shown. A crossover occurred in each of the four regions, and the points of crossing-over are indicated by double headed arrows. The exchanges are effected while the chromosomes are in synapsis. The unsplit *sfa.*'s separate the dyads from each other at the first meiotic division. They have the constitutions indicated at 9*B*. The *sfa.*'s split at the second reduction division and the four chromatids indicated in Figure 9*C* pass to the poles of the second meiotic spindles. They may be arranged in the ascus in eight possible manners as already indicated. Each pair of adjacent ("double") exchanges are classified as 2-, 3-, or 4-strand double exchanges. Enclosing the word *double* in quotation marks indicates that the particular "double" is a pair of adjacent exchanges from a triple or a quadruple exchange. The "double" exchange occurring between regions I and II is a 2-strand "double" exchange, because strands *a'* and *b'* are involved while strands *a* and *b* are not involved. The "double" exchange occurring between regions II and III is also a 2-strand "double" exchange. However, the "double" exchange occurring between regions III and IV is a 3-strand "double" exchange involving a first exchange between strands *a'* and *b'* and a second exchange between strands *a'* and *b*. (The three strands *a'*, *b'*, and *b* participate in this "double" exchange.) Two-strand double exchanges only occur in one way, i.e., if the first exchange is between strands *a'* and *b'* the second exchange is also between *a'* and *b'*; or the first between *a* and *b* the second between *a* and *b*: or *ab'* and *ab'*; or *a'b* and *a'b*. The first and second exchanges of a 2-strand double occur between the same two strands. There is, therefore, only one kind of 2-strand double with respect to the genotypes produced. In contrast, a 3-strand double exchange between any two regions (except regions II and III) may produce either one of two different sets of genotypes. For example, if the exchange in 9*A* had been between *a* and *b'* as indicated by the dotted double headed arrow instead of between *a'* and *b*, the genotypes would have been arranged in the ascus according to the scheme *+G +CP —GP —C*. A 4-strand double exchange like a 2-strand double can only produce one set of genotypes. An analysis of this situation shows that the expectation of 2-: 3-: 4-strand double exchanges is .25: .50: .25.

In Table I, the three columns following "SPORE ARRANGEMENTS"



METHOD OF ANALYSIS

Figure 9

Diagram indicating the method used in analyzing crossing over in a tetrad in which an exchange occurred in each of the four regions. A 2-strand double occurred between I and II; a 2-strand double between II and III; and a 3-strand double between III and IV. This tetrad is classified as a quadruple exchange; I, II, III, IV; 2-strand, 3-strand. The two dyads are constituted as follows:

and

This results in a second division segregation of the allels $c \angle C$ and $g \angle G$ which shows that a crossover has occurred on each side of the *sfa*. The fact that the linkage relation ($G \angle c$ and $g \angle C$) are unchanged shows that this double exchange involved only two strands.

show the numbers of asci in each class. A "complete" ascus is one in which all spores grew to maturity or the genetical constitution of all four genotypes were deduced from the spores which did grow to maturity. If less than four genotypes could be deduced or if the tests for sex were not completed, the ascus is called "incomplete." There are four possible types of "SINGLE EXCHANGES": one for each region. The "DOUBLE EXCHANGES" show all the possible exchanges between any two regions (I and II, II and III, etc.). In many classes no representatives were found. Three of the double exchanges listed under "3-strand, I IV" were incomplete and could not be distinguished from "2-strand, I IV's." This is indicated by asterisks. They were arbitrarily listed with the 3-strand exchanges. Only those triple and quadruple exchanges actually found are listed. About 20 asci were discarded because insufficient numbers grew to infer the genetical constitutions of the others.

Method of Determinlng Exchange Frequencies

The frequency of exchange in each of the four regions was obtained as follows: Seven asci were found with a single exchange in region I. Ten asci were found with 2-strand double exchanges in I and IV. These asci contributed 10 exchanges to the total number of exchanges in both regions I and IV. Finally the 3 quadruple exchanges contributed 3 exchanges each to each of the four regions. Thus the total frequency of exchanges was 40/422 in I: 30/422 in II: 32/422 in III, and 82/422 in IV. This corresponds to frequencies of .095, .071, .076, and .194, respectively. (Since each exchange produces 2 crossover and 2 noncrossover chromatids, the number of centimorgans in each region is obtained by dividing by 2 and multiplying by 100 [Lindegren[7]].)

A logical basis for calculating the probable frequency of multiple exchange in a tetrad (as compared to calculating the probable frequency of exchange between chromatids) is thus established. Crossover data obtained by sampling single *chromatids,* as in Drosophila, do not provide such a logical basis.

In Table II, the frequencies of single, double, triple, and quadruple exchanges between the different regions are calculated. They are contrasted with the observed frequencies. Only about three-

quarters of the calculated number of single exchanges were observed. The total number of double exchanges is equal to that expected; but they are not distributed at random. The double exchanges between I and IV are three times in excess of expectation and make up 81 per cent of the total number of double exchanges observed.

Therefore, an exchange in region I is more frequently accompanied by a second exchange in region IV than would be expected by chance. These two regions are separated by a greater distance than any other two. They are also symmetrically placed with respect to the *sfa*. Twenty-two double exchanges occurred between I and IV, three between II and III, and two between I and III, making a total of 25 between I-IV and II-III compared to two between any other two regions. This makes a total of 25 double exchanges in the two regions symmetrically placed about the *sfa*. (I IV, II III) as compared to two double exchanges in the four regions (I-II, I-III, II-IV, III-IV) asymmetrically placed about the *sfa*. Therefore, the observed frequency of double exchanges in the regions symmetrically placed about the *sfa*. is about 25 times in excess of expectation. This may mean that coiling of the chromosomes about each other, with the coils beginning at the *sfa*. may be a factor in crossing-over. Such coiling is discussed by Darlington.[6] The synapsing chromosomes would be brought into contact at points symmetrically spaced on each side of the *sfa*. (Figure 11.)

The total number of triple exchanges exceeds expectation by 4.5 times and the three quadruple exchanges observed are 70 times in excess of the calculated expectation. The excess of quadruple exchanges strengthens the view that multiple exchanges tend to occur in regions symmetrically arranged about the *sfa*. The figures in Table I under "Frequency of Double Exchange" are represented graphically in Figure 10. They show that there are 30 "double" exchanges between the *two* pairs of symmetrically placed regions (I-IV, II III) as compared with 19 "double" exchanges between the other four pairs of asymmetrically placed regions (I-II, I-III, II-IV, III-IV).

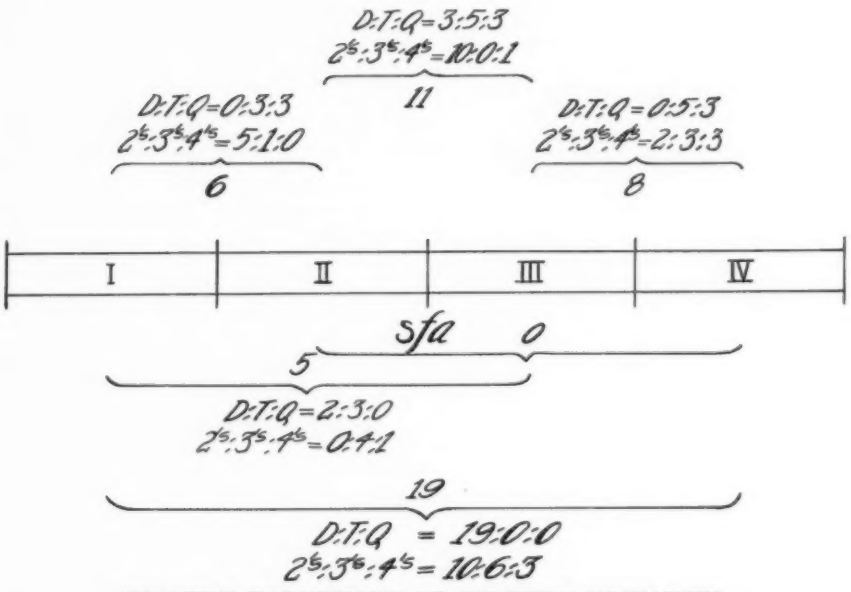
Beneath the heading "FREQUENCY OF DOUBLE EXCHANGES" appear the subheads "TWO-STRAND," "THREE-STRAND" and "FOUR-STRAND." There are twelve 2-strand; eight 3-strand; and four 4-strand double exchanges. Considering each adjacent pair of exchanges in the triple and quadruple exchanges as "double" exchanges, the total data show that the ratio 2-: 3-: 4-strand "double"

TABLE II. Comparison of Observed and Calculated Frequencies of Exchanges in 422 Asci

EXCHANGES	REGIONS	OBSERVED		CALCULATED	OBSERVED/CALCULATED	
NONE	0	290	.687	.687	1.	1.0
SINGLE	I	7	.017	.060	.28	.76
	II	19	.045	.042	1.07	
	III	16	.038	.046	.83	
	IV	52	.123	.143	.86	
DOUBLE	I II	0	-	.007	-	.97
	I III	2	.005	.007	.7	
	I IV	22	.052	.018	2.9	
	II III	3	.007	.005	1.4	
	II IV	0	-	.014	-	
	III IV	0	-	.015	-	
TRIPLE	I II III	3	.007	.0005	14.0	4.5
	I II IV	0	-	.0013	-	
	I III IV	3	.007	.0014	5.0	
	II III IV	2	.005	.0010	5.0	
QUADRUPLE	I II III IV	3	.007	.0001	70.0	70.

TABLE III. Data from Table I analyzed according to the Chromatid Technique

CROSS-OVER	ANALYZED GENOTYPES	NUMBER	TOTAL	FREQUENCY	CALCULATED	COINCIDENCE
NCO	+ G P	704	1401			
	− C	697				
I	− G P	16	39	.0474		
	+ C	23				
II III	+ G C	39	80	.0498		
	− P	41				
IV	+ G	61	127	.0972		
	− C P	66				
II I III	+ P	1	4	.00236	.00245	0.96
	− G C	3				
I IV	+ C P	16	37	.02192	.00475	4.61
	− G	21				
II IV III	+ G C P	0	0	0	.00485	0.00
	−	0				



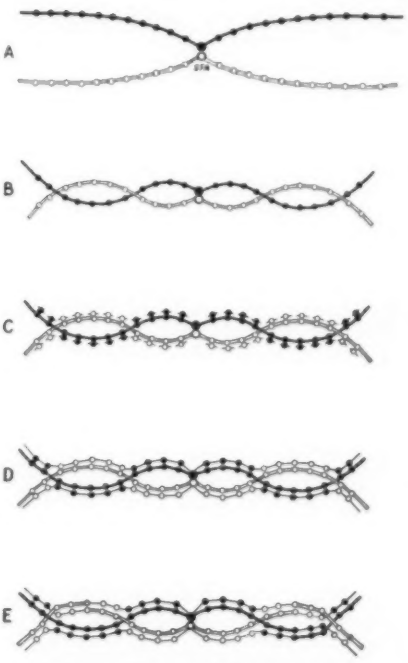
RELATIVE FREQUENCIES OF MULTIPLE EXCHANGES

Figure 10

The number, position, and nature of the multiple exchanges occurring in the four regions studied. The number in each bracket indicates the total number of exchanges involving the two regions indicated. "*D*:*T*:*Q*" indicates how many of these exchanges were double, triple, and quadruple, respectively. "2's:3's:4's" indicates the distribution of 2-strand, 3-strand, and 4-strand exchanges between the regions indicated.

exchanges is 25: 14: 8. This is an observed ratio of .55: .29: .16 instead of the expected ratio of .25: .50: .25. This analysis shows that, contrary to expectation, exchanges between tetrads are usually (1) multiple, (2) symmetrical about the *sfa*. and (3) 2-strand exchanges. These characteristics are not consistent with any current theory of crossing-over. The following scheme is consistent with the facts:

The two leptotene threads synapse in the unsplit stage at the *sfa*'s (Figure 11*A*). They begin to coil about each other (11*B*), and each chromomere produces a "new" lateral chromomere (11*C*). Each "new" chromomere produces two longitudinal strand-buds which eventually unite to produce the "new" strand. By arbitrary definition, a "new" chromomere is one suspended between two recently budded longitudinal strands and an "old" chromomere is one suspended between two of the original strands. At a point where the two chromosomes overlap, due to coiling, a crossover occurs by the union between two new non-sister strands (11*D*). A tetrad with four such overlaps will produce two non-crossover and two quadruple crossover strands. Exchanges will be between the same two strands throughout the chromosome and the crossovers will be symmetrically placed about the *sfa*. Multiple exchanges will occur in those chromosomes in which synapsis, coiling, dividing, and budding are closely synchronized. But chromosomes which have divided and formed new strands before synapsis will not cross over at all. Tetrads will either contain many or no crossovers with a deficiency of single exchanges. The excess of multiple exchanges indicates that



SUGGESTED MECHANISM OF CROSSING OVER

Figure 11

Diagram illustrating how crossing-over might result from (1) coiling of the chromosomes followed by (2) division of the chromomeres and (3) union of non-sister-strand buds at the point where the coiled strands overlap. (*A*) Synapsis of undivided leptotene chromosomes beginning at the *sfa*. The biparental origin of the strands is indicated. The black strands originated from one parent; the white strands from the opposite parent. (*B*) After synapsis at the *sfa*, the two strands begin to coil about each other. Coiling begins at the *sfa*. (*C*) The chromomeres divide and each "new" chromomere (not suspended between two old strands) produces two new strand-buds. (*D*) The adjacent strand-buds unite with each other. This results in the union of sister-strand buds except at the points where the coils overlap. Here the strand-buds from two non-sister chromomeres unite to produce a crossover. Thus two non-crossover and two quadruple crossover strands result from a series of 2-strand "double" exchanges. The excess of this type of exchange and their symmetrical dispositions about the *sfa* makes this mechanism appear to be more plausible than those which the current theories propose. (*E*) Although 2-strand double exchanges appear in excess of expectation, both 3- and 4-strand exchanges are found. They probably arise when a single chromomere is suspended between one "old" strand (represented as a thick strand) and one "new" strand (represented as a thin strand). When one such irregular division of a chromomere occurs in the loop between two chiasmata a 3-strand double exchange results. When one such irregular chromomere division occurs on each loop between two chiasmata, a 4-strand double exchange results.

the union of the new strands usually occurs throughout the chromosome almost simultaneously.

Belling[3] supposed that crossovers resulted from the union of newly budded strands across twists, but supposed that the twists were the result of synapsis. Such twists would seldom be symmetrically placed across the *sfa.* and exchanges near the *sfa.* would be rare. Darlington[6] proposed the crossing-over results from symmetrical coiling of strands about each other during synapsis after the chromosomes had split. He suggested that crossovers were the result of breakage and reunion of strands. Both Belling and Darlington thought that crossing-over preceded chiasma formation. This is in agreement with the present theory. Sax's view[10] that crossing-over follows chiasma formation does not fit the present scheme.

According to Belling's original theory, each tetrad would produce two multiple crossovers and two non-crossover strands. Anderson[1] suggested that exchanges between the four strands were at random, at least towards the ends of the chromosomes. Belling[3] altered his original theory to permit complete random distribution of exchanges between the four strands. He assumed that chromomeres were (1) suspended between two original strands, ("old" chromomeres), (2) between two newly-budded strands ("new" chromomeres), or (3) between one new and one original strand, at random. In Figure 11*E* is shown what would occur if a chromomere retained an original strand on one side and budded out a new strand on the opposite side. (The old strands are thick; the new strands thin, in Figure

11.) This is undetectable, "sister-strand," crossing-over. When one such sister-strand crossover occurs between two chiasmata a 3-strand double exchange is produced. (Figure 11*E*. exchanges below sfa.) When one sister-strand crossover occurs on each side of the loop between two chiasmata, a 4-strand double exchange occurs. (Figure 11*E*, exchanges above *sfa*.) The occurrence of 3- and 4-strand double exchanges is evidence supporting the view that sister-strand crossing-over occurs. But the fact that 3- and 4-strand double exchanges are not found frequently shows that sister-strand crossovers are not so abundant as Belling supposed.

Chromosomes fail to cross over if divisions of chromomeres and the formation of new strands is completed before synapsis. Therefore, delayed synapsis would result in the suppression of crossing-over. This may be the reason that the chromosomes of male *Drosophila melanogaster* fail to cross over. It may be the principal factor operating to reduce crossing-over in inversions.

Darlington[5] proposed that the heteromorphic ends of the sex-chromosomes of *D. pseudo-obscura* did not reassort because the chiasmata formed across the *sfa* were reciprocal (2-strand double exchanges). The present data suggest that the first chiasma across the *sfa* is usually a 2-strand double exchange and support Darlington's view concerning the mechanism which prevents reassortment in this pair of doubly heteromorphic sex-chromosomes.

Muller's[9] principle of interference does not hold in Neurospora, at least not in the form originally proposed in Drosophila. One crossover does not lessen the probability of a second crossover occurring in an adjacent region, but rather if one crossover occurs the probability that a second crossover will occur simultaneously in an adjacent region is increased. But simultaneous crossovers are usually more frequent if the regions are relatively distant. This is because chromosomes usually synapse after the division of the chromomeres is complete, and the two "new" strands have already united. This prevents crossing-over with the second chromosome in the majority of cases. Two strands, in exactly the same condition throughout, do not frequently come into contact. When the synapsing strands are in such a condition that only occasional sister-strand buds are free, or have failed to unite, the distance between crossovers will usually be long because these regions are rarely exactly opposed to each other. Stiffness of the strands is not a factor in preventing contact (and therefore exchange) of synapsed chromosomes. When two *undivided* strands synapse and coil a series of multiple 2-strand exchanges occur.

The difference in the information available in Table I and Table III scarcely needs comment. Much of this follows from the fact that regions II and III are not distinguishable because *sfa* cannot be used as a locus when chromatids are studied.

If the 2-strand double exchanges between II and III were the result of second-division segregation all the conclusions drawn from the present data would still be valid. The genes *g*/*G* and *c*/*C* serve as markers to show when the *sfa*. has unmistakably undergone first-division reduction. Only in 10 of the 422 asci could second-division segregation of the *sfa*. have possibly occurred. This establishes an absolute minimum of first-division segregation of 97.6 per cent. However, the fact that 35 single exchanges occurred in these two regions, together with the fact that the double exchanges between I and IV were mostly 2-strand doubles supports the view that no second-division segregation of the *sfa*. occurred in the asci analyzed in this study.

Summary

Crossing-over in *Neurospora* is not at random. There is a marked excess of 2-strand double exchanges. Crossovers rarely occur singly, but are usually multiple. Multiple crossovers tend to be high in regions symmetrically placed across the spindle-fiber attachment.

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STUDIES IN HUMAN BEHAVIOR

IN one way or another, almost everyone is constantly attempting to control human behavior, their own or somebody else's. Accounts of human behavior constitute by far the greater part of all the literature of the world, and remain a vast storehouse of knowledge garnered by the keenest personal observation. But observational knowledge does not on the whole lead to cumulative results. Each separate effort blazes a new trail, and the ordinary man who must decide practical problems finds doubtful guidance.

Today we turn with new hope to the method of analyzing studies in which the factors affecting behavior are to some extent controlled and defined. Every honest attempt brings a sense of advance. The two books under review are of this sort. They provide summaries of the present stage in the cumulative advance of knowledge of human behavior. They enlarge one's understanding of self and others. Both are stimulating reading. Yet they are sufficiently different in their approach to bring out strikingly the rather tentative nature of the results so far achieved by the scientific method when applied to the study of human behavior.

"Controlling Human Behavior"* covers a large field, over which fundamental research has been unevenly scattered. In spots the conclusions are well supported; in others they seem yielding, as though the structure were too large for its foundations. The first part, "Controlling the Behavior of Self" (369 pages, the major part of the book) has the surest foundations. Psychologists have done important work in this field and their findings are excellently presented. Few people could read certain of these chapters without benefit and an immense sense of personal stimulation. From chapter IV through X, we get new light on "Learning and Habits of Study," on "How to Think," "to Remember," "to Concentrate," "to Use One's Energies Efficiently," "to Control One's Feelings and Emotions." These chapters, and chapter XII on the Selection of Vocation should be of immense value.

In Part II, "Controlling the Behavior of Others," the authors cover a less well charted course. The earlier chapters dealing with children in the home and at school reflect competent psychological studies, and are in contrast to the chapters which follow. We really know less about "Controlling Behavior through Personal Selling" "through Advertising," "through Public Speech," "through Music, Art and Entertainment," which are the subjects of later chapters and

*_Controlling Human Behavior_, by DANIEL STARCK, HAZEL M. STANTON, and WILHEMINE KOERTH. New York: Macmillan, 1936.

dealt out with equal decision. A more tentative approach would have been, to the present reader, more convincing.

In contrast to the scope and authority of "Controlling Human Behavior," the reader may derive a certain comfort from the much smaller work on "Family Behavior."* It is modest in tone. It finds its support from factual material, but recognizes that scientific material is not yet sufficient for a complete interpretation of behavior. To quote from the Preface: "Opinions . . . are quoted from time to time, but always as opinions rather than as demonstrable truths." This will comfort the reader. He, too, has opinions. Miss Cunningham's fine book will make him more cautious about expressing some of them, more certain perhaps of others. In short, it will make him think, and in so doing further the hope of the author that her book may "encourage a questioning attitude towards family problems, . . . and in time contribute to a workable philosophy of family life." In the present stage of scientific knowledge of human behavior, there can be no finer attitude in which to write a book. "Family Behavior" reflects this attitude throughout. It is stimulating, instructive reading in the field which has been better covered by the experimental psychologist than have most other aspects of life.

Both of these books tell us about human behavior under the conditions of modern life. It remains possible that human nature contains untapped resources of self denial, and of aspirations, which under conditions different from those of modern life could be brought out and made use of for the common good. So long as such possibility exists, the exposition of present knowledge will be convincing in proportion as it is modest and tentative.

In the long run, no greater injury could be done to the usefulness of science than that which would occur from the premature acceptance of unsound conclusions concerning the control of human behavior. Human attitudes, whatever their origin, determine man's choice as to size of family. Only to such a degree as the development of human attitudes is wisely controlled, can the science of genetics hope to play its vital part in the improvement of the race.

FREDERICK OSBORN.

Family Behavior, by BESS V. CUNNINGHAM, PH.D. Philadelphia: W. B. Saunders & Co.

◆

INFORMATION SERVICE FOR RESEARCH WORKERS IN HUMAN GENETICS

ONE activity contemplated in setting up the Clearing-House for Human Heredity is the organization of information service for research workers in the subject. The value of such a plan has been demonstrated in the information service already established for workers on Drosophila, etc. It should be noted that apart from convenience of ascertaining easily centres at which comparable work is going on, the circulation of notice by those engaged in a particular enquiry of their work is a safeguard in dating priority — a point to which it is natural to attach some importance.

Workers are requested to address to the bureau a short paragraph describing the work on which they are engaged. These notices will be multiplied and circulated to all those co-operating. In the first instance this bulletin will be issued every twelve months. Later supplementary bulletins will be issued more frequently.

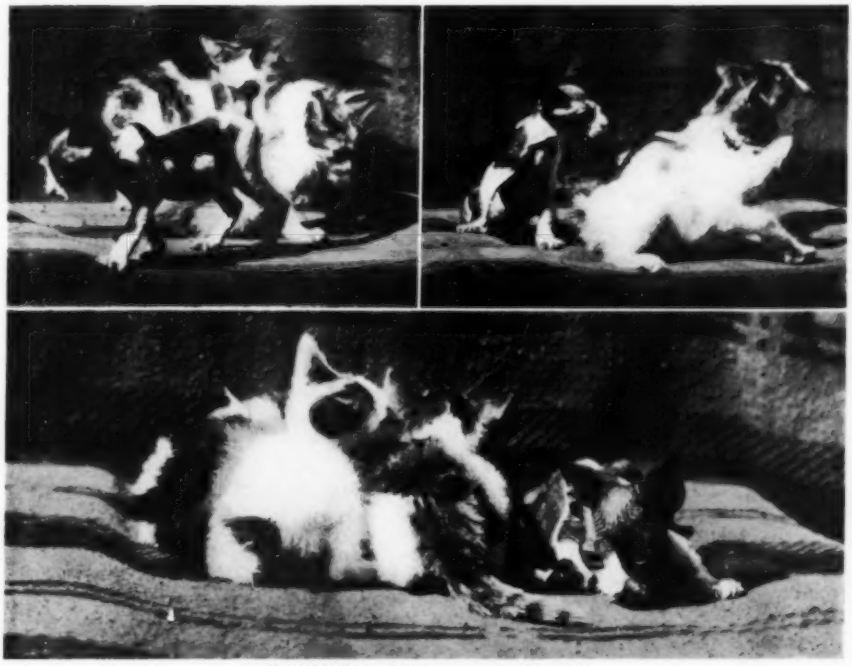
Those using this service are asked to subscribe 5/-, a sum equalling approximately one quarter of a pound sterling equivalent in the currency of their country.

The accepted languages are: French, German, English.

(MRS.) C. B. S. HODSON,
Hon. Gen. Sec.
Bureau of Human Heredity,
115 Gower St., London, W. C. 1.

A "CAT-DOG" FROM NORTH CAROLINA

Hairless Gene or "Maternal Impression"?



HAIRLESS CAT OR CAT-DOG

Figure 12

Three views of an abnormal kitten which appeared in a litter of four, only one of which was normal,—two of the others being short tailed. The genetic nature of this variation is unknown, but it has a striking resemblance to some of the genetic hairless forms in rabbits and mice.

AROUND the middle of August, 1936, a curious litter of kittens was born to a perfecly ordinary appearing pet cat, belonging to Mrs. Annie Mae Gannon, of Wilmington, N. C.

Of the entire litter, only one of the kittens is perfectly normal in appearance—the other three being freaks. One of the cats has no tail at all; another has only a stub of a tail. But the extraordinary member of this feline family is the fourth—well, we can hardly call *it* a cat—so for want of a better name, we'll call it a "Nonesuch."

It is said that before the kittens were born, the mother cat was often engaged in fights by a mixed-breed dog in the neighborhood, and on several occasions was badly frightened by the dog. This is about the only plausible explanation as to why the "nonesuch" is so unusual in appearance. In fact, this little animal—now about two months old—is about the queerest looking creature one could hope to set eyes upon. Its face is that of a black, white, and yellow spotted dog. Its ears are quite long and sharp-pointed. It has the short whiskers of a puppy. The hind legs are amusingly bowed. It has a stub tail. What makes

the nonesuch even more unusual appearing is the short smooth dog hair all over its cat-like body.

From the very moment of its birth, which was about *twelve hours* after the rest of the litter, the nonesuch was surprisingly independent in its actions. It was born with its eyes *open*, and was able to crawl a little—two characteristics quite unknown to new-born kittens.

The nonesuch acts both like a cat and a dog. While it makes a noise like a cat, it sniffs its food like a dog. Nothing delights the nonesuch more than gnawing a bone in a very dog-like manner.

When resting, little nonesuch places its paws straight out in front just as a dog would do. The little creature doesn't relish playing with the rest of its family, being entirely contented in stretching out and watching the others frolic about.

HENRY STERNBERGER
Wilmington, N. C.

EDITOR'S NOTE: *Geneticists would be more inclined to ascribe the appearance of the unusual animal described above to the action of a recessive mutation than to the ancient doctrine of maternal impressions. If the curious kitten does represent a mutation, it is one of no little genetic interest, as offering a further parallel between mutations in the cat and the rabbit.* (*See Keeler and Cobb,* JOURNAL OF HEREDITY 24:181-184. *May* 1933). *To judge from Mr. Sternberger's pictures and the description, "Nonesuch" must rather closely resemble the Rex rabbit.*

It was hoped that it might be possible to obtain "None-such" and test the matter genetically. Unfortunately his owner is reported to feel that this unusual creature should be so valuable for museum or sideshow purposes as rather to put it out of range of genetic experimentation. In a later letter from Mr. Sternberger we learn that all the other members of the litter have died, so that there seems little hope of being able to do more than record the occurrence of this odd form.

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Twins with Tuberculosis

(*Continued from page* 91)

1. Those with tuberculosis in only one member of the pair. This group included 68 fraternal and 16 identical pairs.

2. Those with great intra-pair differences in tubercular tendencies. Of this type there were 5 identical and 21 fraternal pairs.

3. Those with the same or closely related tubercular tendencies in both members of the pair. This group included 48 identical and 27 fraternal pairs.

Of the 16 pairs of identical twins with only one member tubercular, in each instance some unusual environmental condition was present, which possibly accounts for the intra-pair differences.

The investigation indicated that a hereditary tubercular tendency is always more specifically manifest with increasing age. The authors conclude that the greater similarity in tubercular tendencies in the identical twins unquestionably proves that susceptibility to tuberculosis has a definite genetic basis. The last two chapters discuss the pathological and practical significance of their findings, and conclude with remarks on the twin method of research.

The material is well organized and written in a logical, clear-cut style. The authors' findings emphasize the fact that we have only begun to take advantage of the twin method of research. Especially is this true in the United States, many other countries, especially Germany and Russia, being more to the fore in large scale twin projects.

D. CECIL RIFE
Ohio State University

THE TRANSMISSION OF BREAST AND LUNG CANCER IN MICE

JOHN J. BITTNER and C. C. LITTLE
Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine

THE availability of inbred strains of mice has made possible various tests on the inheritance of the susceptibility of cancer in mice. The strains which have been used by the Jackson Laboratory group are listed in Table I. Only the breast tumor data are mentioned. They are based on the percentage of the animals living to the beginning of the earliest cancer age period or longer which eventually developed this type of tumor. The average tumor age cannot be given for some stocks as it was not stated in the publications. The high cancer strains, in the order of incidence in breeding females, are *A, C3H* and *dba* (dilute brown). This order also corresponds to the degree of inbreeding for these strains. The low tumor lines are *C57 Black* (*B*), *CBA* (*X*), *N*, and *Mus Bactrianus*. Most of the strains have been inbred for 20 or more generations by brother-to-sister matings.

In the second table is listed the experiments, by authors, which support the theory of extra-chromosomal influence in the transmission of breast cancer in mice. This hypothesis was advanced by the Staff of the Jackson Laboratory in 1933.[19] The experiments in which the back-cross generations were tested are not given in the table but were published by Murray and Little[16,18] and Korteweg.[9-11] A cross between two high tumor strains (*A* and *dba*) has also given confirmatory evidence.[3]

A few of the tumors observed in the cross *dba* × *C57 Black* by Murray and Little[17] were not of epithelial origin. Their percentages are quoted, however, in Table II. For the revised diagnoses see Cloudman.[21] An article by Cloudman, Bittner, and Little[22] gives additional data for the *C57 Black* stock. The number of breeding and virgin females observed were 386 and 97 and the percentages which had breast tumors were 1.0% and 0.0% respectively.

It will be observed from the table that in every cross the incidence of breast tumors in the hybrid generations is greater when the high tumor mother was used than when the reciprocal cross was made. Also, the breeding hybrid mice showed a higher incidence of mammary tumors than any of the pure stocks.

In Table III are listed the observations on the animals which have died in the cross between the *A* and *C57 Black* stocks. The numbers represent only a small proportion of the animals which are included in the experiment. The others are still living.

The incidence of tumors in the *A* stock mice is: breeding females, high mammary, low lung; virgin females, low mammary, high lung; and males, high lung (Tables I and IV). The breast tumors are medullary or adenocarcinomas; the lung tumors are bronchial carcinomas. They have been diagnosed by Dr. A. M. Cloudman. The *C57 Black* stock mice do not have more than 1.0% with breast tumors and the lung tumor incidence is even smaller.

Tumor-Incidence in Hybrids

In designating the generations the maternal stock is given first, i.e., *AB* $F_1 = A ♀ \times C57\ Blk.\ (B)\ ♂$, etc. The reciprocal cross was termed the BAF_1 generation.

The incidence of breast tumors in the *AB* F_1 and *AB* F_2 hybrid breeding females is very high (98.3% and 96.4% respectively). In all other female classes the proportions having this type of tumor are very small and they approach

TABLE I. Tabulates by authors the incidence of mammary gland cancer in low and high tumor stocks.

	High Cancer Stocks	Incidence in Breeding ♀♀			Incidence in Virgin ♀♀		
		No.	% Ca.	Aver. Age	No.	% Ca.	Aver. Age
Murray (15)	dba	2352	58.7%	10.6 Mo.			
Murray (Data given to author - 1936)	dba	?	76.0%	?			
Murray & Little (17)	dba				297	50.8%	?
Korteweg (11)	dba	61	76.3%	12.7 Mo.	197	72.1%	12.5 Mo.
Bittner (2, 5, 6)	A	786	83.2%	11.5 Mo.	344	4.9%	17.5 Mo.
Bittner (1)	C3H	200	78.0%	11.4 Mo.			
	Low Cancer Stocks						
Murray & Little (17)	C57 Blk.	240	0.0%				
Korteweg (11)	C57 Blk.	59	1.7%		194	0.0%	
Staff (19) (Green)	M. Bact.	?	2.0%				
Strong (20)	CBA	71	2.8%				
Bittner (7, 8)	CBA	125	13.9%	21.0 Mo.			
Bittner (7)	W	102	6.8%	16.8 Mo.			

TABLE II. Some of the experiments confirming the extra-chromosomal influence for breast tumor susceptibility. The average age for the total number of hybrids is given in some crosses and the average breast cancer age.

	STOCKS MATED		1st GENERATION HYBRIDS					2nd GENERATION HYBRIDS			
	High Ca.	X Low Ca.	Hybrids	Total No.	Age	% Cancer	Average Ca. Age	Total No.	Age	% Cancer	Average Ca. Age
Staff (19) Murray & Little (17)	dba ♀	x C57 Bl. ♂	Virgins	113		39.8%		664		35.5%	
	dba ♂	x C57 Bl. ♀	Virgins	379		6.1%		687		6.0%	
Staff (19)	dba ♀	x M.Bact. ♂	Virgins	69		66.1%		118*	17.2	39.8%	17.2
	dba ♂	x M.Bact. ♀	Virgins	27		7.4%		86*	21.1	7.0%	21.4
Staff (19) Bittner (7)	A ♀	x CBA ♂	Breed.	44	14.7	90.9%	14.9				
	A ♂	x CBA ♀	Breed.	16	25.1	31.3%	25.7				
Staff (19) Bittner (6, 7)	C3H ♀	x I ♂	Breed.	36	10.1	91.7%	10.4				
	C3H ♂	x I ♀	Breed.	10	22.5	0.0%					
Korteweg (9-11)	dba ♀	x C57 Bl. ♂	Breed. & Virgins	7		100.0%		8		87.5%	
	dba ♂	x C57 Bl. ♀		67		3.0%		100		4.0%	
Bittner (7)	C3H ♀	x W ♂	Breed.	46	9.8	97.9%	9.7	4		75.0%	
	C3H ♂	x W ♀	Breed.	18 *	23.2	27.8%	18.0				

* Tabulated from Green's data.

TABLE III. Mice of the F_1 and F_2 generation of the cross between the A and C57 Blk. (B) stocks. The proportion of breast and primary lung tumors is given as well as the average ages for the total number and average tumor ages.

	Total		Breast Cancer		Lung Cancer		Non-Cancer	
	No.	Aver. Age	Per Cent	Aver. Age	Per Cent	Aver. Age	Per Cent	Aver. Age
ABF_1 Breed. ♀♀	56	9.9	98.3%	10.0	0.0%		1.7%	9.9
BAF_1 Breed. ♀♀	22	17.5	13.6%	12.3	36.4%	19.9	50.0%	17.1
ABF_2 Breed. ♀♀	28	9.3	96.4%	9.3	0.0%		3.6%	9.1
BAF_2 Breed. ♀♀	8	11.5	0.0%		0.0%		100.0%	11.5
ABF_1 Virgin ♀♀	21	20.6	4.8%	19.6	57.1%	21.9	38.1%	18.8
BAF_1 Virgin ♀♀	13	21.9	0.0%		69.2%	22.6	30.8%	20.3
ABF_2 Virgin ♀♀	16	15.2	11.1%	10.9	22.2%	16.0	66.7%	13.6
BAF_2 Virgin ♀♀	15	14.5	0.0%		40.0%	14.8	60.0%	14.3
ABF_1 ♂♂	19	21.6	0.0%		57.9%	22.6	42.1%	20.2
BAF_1 ♂♂	16	17.0	0.0%		56.3%	18.5	43.7%	17.4
ABF_2 ♂♂	13	15.2	0.0%		15.4%	15.1	84.6%	15.2
BAF_2 ♂♂	27	15.4	0.0%		37.0%	17.2	63.0%	14.3

TABLE IV. Gives the breast and lung tumor incidence in A stock mice, fostered animals and hybrids between the A stocks and the C57 Black (B) and CBA (I) low tumor lines.

	No.	Breast Ca. %	Lung Ca. %
A Stock - Breeding ♀♀	788	87.2%	3.7%
AB x CBA^{F} = ABI_1 Breed. ♀♀	44	90.0%	0.0%
AB x C57 Bl.^{F} = ABB_1 Breed. ♀♀	58	98.3%	0.0%
ABI_1 x ABI_1 = ABI_2 Breed. ♀♀	28	96.4%	0.0%
A Stock - Virgin ♀♀	284	4.9%	84.8%
A Stock - ♂♂	116	0.0%	71.6%
CBA or I Stock - Breed. ♀♀	125	13.9%	—
A Stock - Breed. ♀♀ Fostered by CBA or I ♀♀	51	23.1%	44.0%
AF x $CBAF$ = AFI_1 Breed. ♀♀	16*	31.3%	75.0%
A Stock - Breed. ♀♀ Fostered by C57 Bl. or B ♀♀	41	4.9%	48.8%
AF x C57 Bl.^{F} = BAF_1 Breed. ♀♀	22	13.6%	36.4%
BAF_1 x BAF_1 = BAF_2 Breed. ♀♀	8	0.0%	0.0%
ABF_1 Virgin ♀♀	21	4.8%	57.1%
BAF_1 Virgin ♀♀	13	0.0%	69.2%
ABF_1 ♂♂	19	0.0%	57.9%
BAF_1 ♂♂	16	0.0%	56.3%

* 2 Multiple Tumors.

that of the *A* stock virgin females.

Lung tumors were recorded in approximately the same ratios, allowing for the age differences and small numbers, in the *AB* F_1 and *BA* F_1 virgin females and males—56.3% to 69.2%. The F_2 classes showed from 15.4% to 40% of lung tumors. The ages of these mice are considerably below the expected lung tumor age.

In another experiment the proportion of breast tumors observed in breeding *A* stock female has been significantly reduced by fostering for one generation to low tumor stock females. Mice of subsequent generations nursed their *A* stock mothers.[4,8]

The incidence of breast tumors for the two series fostered by *CBA* and *C57* Black females is given in Table IV. They were 23.1% and 4.9% respectively as compared with 83.2% in the controls. The average tumor ages were the same in every group. The average ages at death for all the mice in each series were: *CBA* fostered, 14.8 months; *C57 Black* fostered, 16.5 months; and the control *A* stock group, 11.7 months.

Although the mice of the fostered series were kept under the same conditions, lived longer than the controls, and were subjected to the same irritation factors considered to be essential for the development of tumors in the *A* stock breeding females, fewer tumors were observed. These differences were explained as probably due to some "breast cancer-producing influence" which was transmitted through the milk to mice which nurse *A* stock mothers. The mice which were fostered by low tumor line femals obtained little or none of this influence and thus fewer developed breast cancer.

Table IV also tabulates the breast and lung tumor data in normal and fostered *A* stock mice and the *A* stock hybrids.

The incidence of breast tumors is high in breeding females of the *A* stock and the hybrid female groups which had *A* stock mothers: *A* stock, 83.2%; *AX* F_1, 99.9%; *AB* F_1, 98.3%; and *AB* F_2, 96.4%. (There is no reduction in the F_2 breeding females as would be expected on any genetic explanation.) In the reciprocal crosses the ratios are more like that for the *A* stock virgin females and/or the low stock breeding females. They also approach the incidence in fostered *A* stock breeding females for the respective stocks. These percentages are: *A* stock virgin females 4.5%; *CBA* or *X* stock breeding females 13.5%; *CBA* or *X* stock fostered *A* stock breeding females 23.1%; and *XA* F_1 breeding females 31.3%. The *C57 Black* or *B* stock series showed the following ratios: fostered *A* stock breeding females 4.9% and *BA* F_1 breeding females 13.6%. These figures are very close to the incidence in the *A* stock virgin class.

Lung Tumors Genetically Determined

The ratios of spontaneous lung tumors in hybrid virgin females and males of the *A*×*B* cross show little difference regardless of maternal or paternal parent from the high tumor line. No variation would be expected as lung tumor susceptibility is not affected by extra-chromosomal influences and is probably transmitted by means of one or more dominant genetic factors by either parent.

Lynch[12,13] found lung tumors in hybrids made by mating individual males of a 40% lung tumor line to females of a low line. The lung tumor line was not inbred. Lynch stated that lung tumor susceptibility was inherited as a dominant or semi-dominant character. MacDowell and Richter[14] found that hybrids which had the paternal parent from a high inbred leukemic stock had a ratio of 42.5% of leukemia. In the cross where the maternal parent was from the high leukemic line the incidence was 61.9%. MacDowell and Richter explained their results as being due to extra-chromosomal or maternal influences. They eliminated the mother's milk by fostering experiments. Thus, unless reciprocal crosses are made it is impossible to state the exact

nature of the inheritance or transmission of cancer susceptibility.

Breast Tumor Depends on Carcenogenic Agent

To explain the extra-chromosomal influence in breast tumor etiology the theory is tentatively advanced that breast tumor development is dependent primarily on a "breast cancer-producing influence" which is transmitted through the milk of the high breast cancer stock female to her progeny—hybrid or pure strain individuals. Females of the high breast tumor stock following fostering by low tumor stock mothers showed a marked decrease in their breast tumor incidence. A few *C57 Black* females which were fostered by *A* stock mothers have developed breast tumors. Hybrids which have low tumor stock mothers show a low breast tumor rate; hybrids which have high tumor stock mothers show a high tumor rate. *A* stock breeding females and hybrids which had fostered or maternal parents from the same low tumor stock showed a correlation between their tumor ratios. This hypothesis would also account for the same incidence of breast tumors in breeding F_1 and F_2 females which had high breast tumor stock mothers. No influence was observed on spontaneous lung carcinoma.

Additional work by one of us (Little) is associated with this theory and gives supporting data. Fertilized ova from dilute brown (*dba*) females were removed within 24 hours after impregnation and were transplanted to the oviducts of *C57 Black* females. The dilute brown females obtained by this procedure were, after being nursed by the *C57 Black* "mothers," used as breeders.

Murray[15] observed that the average tumor age in dilute brown breeding females was 10.5 months. The earliest tumor to be recorded was in an individual which was 3.5 months. In virgin females of this stock the earliest tumor appeared at 8.5 months and the average tumor age was 16.6 months (Murray and Little[17]).

In the group of dilute brown mice descended from transplanted eggs 61 females survived 6 months or longer and 46 lived over 8 months. The average age of the 41 living mice is 11.5 months. Seventeen are over one year old, average age 14.5 months. No tumors have been observed in any of these mice.

As the mice of this group were unable to obtain any milk from dilute brown mothers a possible explanation may be offered for the observance of growths in the *A* stock fostered groups. They were probably due to the small amount of milk which some of the young obtained before they were removed from their *A* stock mothers and fostered to low tumor stock females.

Conclusions

The extra-chromosomal theory explains the occurrence of spontaneous breast carcinoma in the hybrids made by mating the high tumor *A* stock and the low tumor *C57* or *B* stock.

The extra-chromosomal theory does not explain the transmission of spontaneous lung carcinoma.

Lung tumor susceptibility may be transmitted by the maternal or paternal parent of the high lung tumor stock in accordance with genetic principles. One or more dominant factors are probably involved.

The decrease in the incidence of breast cancer in breeding *A* stock females fostered by low tumor stock mothers was probably due to the absence of a "breast cancer-producing influence" which is transmitted in the milk of breast cancer mothers.

The development of mammary tumors in low tumor stock mice which were fostered by high tumor stock mothers may be explained by an extension of this thesis.

The extra-chromosomal or maternal influence observed in breast tumor crosses may tentatively be attributed as due to a "breast cancer-producing influence" obtained by the progeny from the milk of breast cancer line mothers.

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Books Received

BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the JOURNAL *will be reviewed in later numbers.*

THE EMERGENCE OF HUMAN CULTURE, *by* Carl J. Warden, Assistant Professor of Psychology in Columbia University. Pp. 189. Price, $2.00. New York: The Macmillan Company, 1936.

RESEARCH IN DEMENTIA PRECOX (Past Attainments, Present Trends and Future Possibilities), *by* Nolan D. C. Lewis, M.D., Professor of Neurology, Columbia University, Associate Medical Director, Neurological Institute of New York, Field Representative and Coordinator of Research in Dementia Precox Founded by the Northern Masonic Jurisdiction of the Scottish Rite. Pp. 320. Price, $1.50. New York, National Committee for Mental Hygiene. 1936.

THE FUTURE OF MARRIAGE IN WESTERN CIVILIZATION, *by* Edward Westermarck, Late Martin White Professor of Sociology in the University of London. Pp. 281. Price, $2.50. New York: The Macmillan Co. 1936.

MISCENGATION, A Study of the Biological Sources of Inheritance of the South African European Population, *by* George Findlay. Pp. 48. Price, 1/6. Pretoria: The "Pretoria News" and Printing Works, Ltd. 1936. (From J. L. van Schalk, Ltd., Pretoria.)

INTRODUCTION TO SOCIAL RESEARCH, A Text and Reference Study, wherein are presented various methods of social research in a compact, convenient form. *By* Emory S. Bogardus, Ph.D. Pp. 237. Price, $3.00. Los Angeles: Suttonhouse, Ltd. 1936.

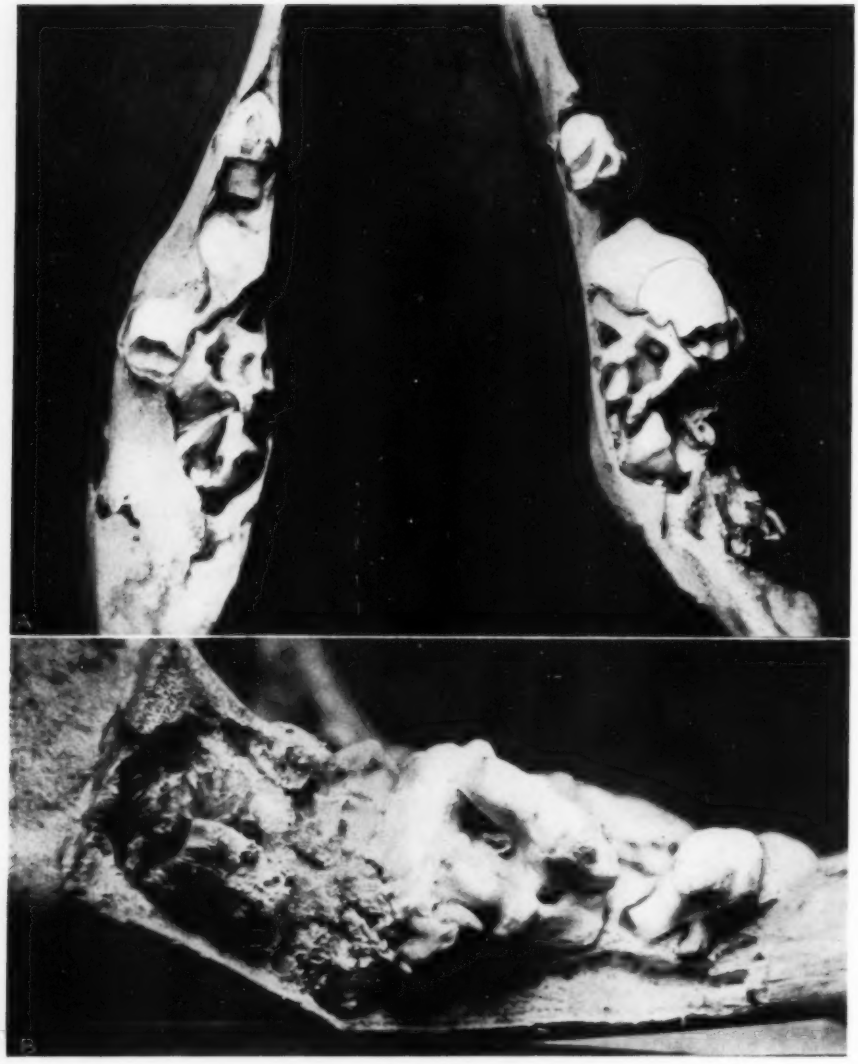
UNCONVENTIONAL ETHICS, The Ethics of Tomorrow, *by* Osias L. Schwarz. Pp. 276. Price, $3.50. Washington: Perennial Publications. 1936.

MOVEMENTS OF THOUGHT IN THE NINETEENTH CENTURY, *by* George H. Mead, Late Professor of Philosophy, the University of Chicago; Edited by Merritt H. Moore, Professor of Philosophy, Knox College. Pp. 519. Price, $5.00. Chicago: University of Chicago Press. 1936.

SEX AND PERSONALITY, STUDIES IN MASCUINITY AND FEMINITY, *by* Lewis M. Terman and Catherine Cox Miles. Pp. 600. Price, $4.50. McGraw-Hill Book Co., New York and London. 1936.

ANIMAL BREEDING PLANS, *by* Jay L. Lush, Professor in Animal Breeding, Iowa State College. Pp. 350. Price, $3.00. Ames, Iowa: Collegiate Press, Inc. 1937.

ON YOUR GUARD! The Prevention and Treatment of Sex Diseases. *By* Carl Warren, B.A., B.S., M.S.J., Advised and Assisted by Eminent Specializing Physicians. Pp. 160 Price, $1.00. New York City: Emerson Books, Inc. 1937.



DETAILS OF TOOTH DEFECTS

Figure 13

Close-up dorsal view (*A*) of lower jaw of defective calf VI-2. The astonishing state of disorder in which the teeth are found is easily seen. The other view is a lateral view of the jaw of this same animal with the bone removed to expose the teeth. Some of the teeth are growing at an angle of over 90 degrees from the normal. It is interesting that no other pathological conditions were noted in a careful examination of these calves. The complete break-down of one part of the developmental mechanism has not grossly affected other parts.

IMPACTED MOLARS -- A NEW LETHAL IN CATTLE*

EDWIN E. HEIZER AND MARSHALL C. HERVEY
Ohio State University

FOR some time it has been felt that there were, at best, very few characters of economic importance in domestic animals which were inherited in a simple Mendelian fashion. However, more recently, studies on the inheritance of lethals have shown that characters inherited in such a manner are of great practical importance to the animal breeder.

Lethal characters are quite prevalent in cattle, and dairy cattle in particular. Of the 31 lethal characters in domestic animals described by Hutt,[8] 11 affected cattle. To that list now can be added the condition, impacted molars, and another lethal to be described soon, agnathus. It is of interest to note that Williams[18] states that every tabulation of monsters in domestic animals shows a marked preponderance in dairy cattle.

It is quite possible that there are many inherited lethals which we are unable to recognize. Some characters may exert their lethal effects quite early in embryological life and the monsters which have demonstrated the presence of other lethals may not be formed or delivered. Williams in this connection says, "So far as can now be determined about one-half the fertilized ova of domestic animals perish and disappear unseen." Not all of these cases, however, should be attributed to the action of lethal genes.

Crew[3] in 1923 presented evidence to show that the bulldog or achondroplasia-like calf which frequently appears in the Dexter breed of cattle is due to heritable factors. The Dexter breed is composed of animals which have been selected for small size, short legs, and short broad heads.

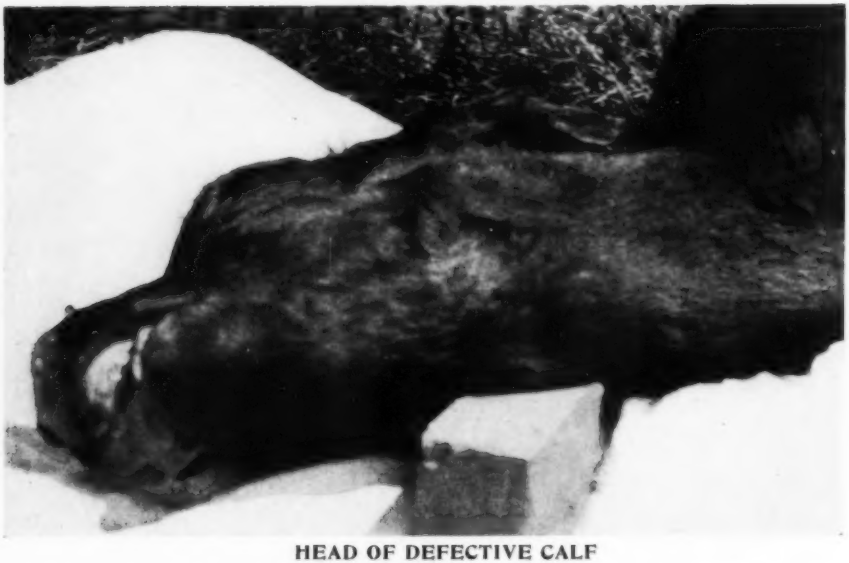
The bulldog calf of the Dexter breed shows conditions similar to those of achondroplasia in man. The cranium is bulging, the nose depressed, the upper lip split, and the swollen tongue is thrust out and up over the nose. In these calves the tail is situated high on the back. Umbilical hernia is frequently associated with this condition. The limbs are extremely short, so short in fact that often it appears that only the digits are protruding from the body. Recurrent hydrops amnii occurs in such a gestation and delivery is difficult and usually before term.

Seligman[15] in 1904 described the above condition in Dexter cattle as cretinism and as being due to placental disease, but noted that some individuals seemed to sire or deliver a large number of the so-called cretins. Crew, however, suggests that the primary cause of this condition is a malfunctioning of the pituitary in the second or third month of intra-uterine life.

The Dexter breed is believed to have originated from the crossing of the Irish Kerry cattle with the Red Devon. Crew advanced the following hypothesis to explain the inheritance of this abnormality:

> During the formative period of the breed two independent mutations occurred. Each of these resulted in the appearance of a factor L_1 and L_2 respectively, the action of which intensified the action of the factors which resulted in the production of the low grade of achondroplasia-like condition. L_1 and L_2 are modifying amplifying factors and their action is additive. Either alone produces a greater degree of the "achondro-

*This condition was first brought to the attention of the Senior author by Dr. L. H. Snyder, of the Department of Zoology, Ohio State University, to whom it was reported by a student.



HEAD OF DEFECTIVE CALF

Figure 14

Lower view of head of defective calf, showing "parrot jaw" effect produced by impacted molars. The calves live only from a few hours to a week after birth. The jaw defects are the only visible abnormalities and it has not been determined why this defect results so quickly in death.

plasia" characterization and together they yield the highest grade which is seen in the non-viable "bull-dog" calf. The "lethal" constitution is SS + L_1 + L_2. These mutations occurred in the early Dexter and not in the parental breeds, and would seem to be linked with the factor *S*. [S—short-legged stout conformity.]

The lethal mutations were assumed to be linked with *S* and not with *s*, the factor for the long-legged rangy conformation of one of the parent breeds, the Kerry. Conclusive evidence in support of the above hypothesis has not been presented. Hutt calls this condition "dominant" achondroplasia in contrast to "recessive" achondroplasia.

Wriedt[16] and Mohr[9] have described a similar but less extreme condition in the Telemark cattle of Norway. The parents are normal in this case and not short-legged and brachycephalic as are the Dexter cattle. Since the parents are normal this type of achondroplasia is recessive in its inheritance. Punnett[13] reports the experiments of T. H. Riches which prove that the Dexter and the Telemark monsters are due to entirely independent genes.

Similar "Dexter Monsters" or "bull-dog calves" showing varying degrees of achondroplasia have been described in other breeds. Downs[4] reports the case of a "Dexter Monster" produced from a Jersey cow mated to a Holstein bull. This cow had previously dropped a bull-dog calf by an unknown sire. Carmichael[1] describes a number of such calves being produced in the Nganda cattle of Africa.

A condition of an imperfect epithelium (epitheliogenesis imperfecta) in Holstein cattle has been shown by Hadley and Cole[5,6] to be a simple recessive character. The lesions are most common on the legs below the knees and hocks, on the muzzle, and on the ears. These lesions are practically identical in all cases and bilaterally symmetrical. The calves are born alive at full term but die from septicaemia caused by bacterial invasion through the lesions of

DETAILS OF IMPACTED MOLARS

Figure 15

Dorsal view of jaw of defective calf showing impacted molars. At birth the eight incisors and the pre-molars normally have erupted in cattle. The space occupied by the pre-molars is markedly reduced from the normal. The pre-molar teeth in this space are simply a jumble of dental odds and ends,—the teeth lying in all directions. The germs (anlagen) of the molars are also misplaced and disarranged. So great is the stress that the jaw has been broken by this abnormal growth. The break is easily visible on the left.

the skin and mucous membrane. This condition appears in animals closely linebred to Sarcastic Lad or the Johanna family. The same defect has been observed in Holland in animals thought to have similar ancestry.

In the Holstein cattle in Sweden a condition of lethal hypotrichosis (hairlessness) has been noted by Mohr and Wriedt.[11] The calves are almost completely hairless, hair being present only in certain limited well-defined areas. Where hair is present histological sections of the skin show a normal appearance but where it is absent it can be seen that the development of the hair follicles is markedly delayed and that the sweat glands have undergone premature development resulting in cystic enlargement. The calves are born alive but die within a few minutes, probably due to inadequate heat regulation of the body. The character is a simple recessive.

Another lethal character occurring in the Swedish Holstein cattle is acroteriaus congenita or "amputated." Wriedt and Mohr[17] state that the most striking feature is the "amputation" of the forelegs to the elbow joint and the hind legs to the hock joint. The ends of the legs are blunt and round and covered with hairy skin. This condition is accompanied by an atrophied maxilla, a markedly atrophied mandible, and a cleft palate. The upper jaw in addition to being atrophied is turned down, the result being that it has a somewhat parrot-bill appearance. Only the vestiges of the lower jaw are present and there are but three irregularly planted teeth located in the foremost part. No other teeth or rudiments are present in the lower jaw. These calves are delivered at full term and are of normal size but are dead or die immediately on birth. This condition is inherited as a simple recessive.

A lethal condition described as "Short Spine"[12] occurs in the Oplandske mountain breed of cattle of Norway. There is an extreme shortening of the vertebral column particularly in the cervical and thoracic regions, and a reduction in the number of ribs. The head and extremities are normal, however, and no pathological changes were found in the internal organs. Atresia ani is present in some cases. The calves are delivered at full term and die during or immediately after birth. Suffocation during parturition is the cause of death in many cases. This condition has likewise been proved to be due to a simple recessive.

Mohr[11] in Norway and Hutt[7] in Minnesota have discovered lethal muscle

contractures in Holstein cattle which appear to be identical. This condition is characterized by extreme rigidity of the neck and limbs. Because of the extreme dystocia encountered in parturition the mother may be injured, in some cases fatally. This character is inherited as a simple recessive.

Loye (cited by Hutt[8]) found Red Danish calves which were born alive and apparently normal in all respects except that they could not stand on their hind legs. Even when unusual care was given the lameness persisted and all calves showing this trait had to be slaughtered. The evidence indicates that this is also a simple recessive.

Ljutihow (cited by Hutt[8]) reports a simple recessive lethal in a Swiss breed in Russia. Little description was given of the defect. Mohr (also cited by Hutt) has described briefly a recessive character in which the lower jaw is shortened and ankylosed.

Regan, Mead, and Gregory[14] first reported a hairless condition in Jersey calves which was due to a single recessive gene. Wipprecht and Horlacker[17] shortly later reported a similar condition in another herd. Regan, et al, state that this condition is almost identical with that described by Hadley in Holstein cattle. Parts of the body are hairless; there is no skin below the knees or hocks, around the eyes, or on the muzzle, and localized areas of the body elsewhere are devoid of skin. Cook[2] shows that the sire of the bull producing the defective calves in the Texas herd (reported by Wipprecht) is the grandsire of the bull producing defective calves in the California herd, and the sire of the California bull is the grandsire of the Texas bull. He concludes that the same genes are operating in both herds.

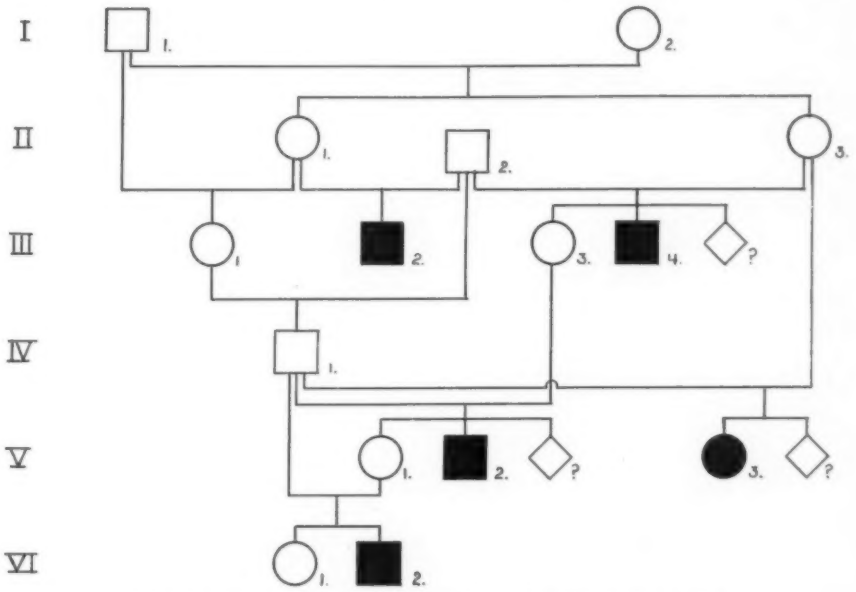
Description of the Defect

The condition of impacted molars in calves born alive at full term was found in a herd of closely inbred Milking Shorthorn cattle in central Ohio. These calves were of normal size, and produced no visible abnormal conditions during the gestation period as far as is known. Calves showing the defect died within the first week after parturition.

Cattle normally have 32 teeth, 8 incisors on the lower jaw (incisors are absent from the upper jaw), 6 premolars and 6 molars on both upper and lower jaws. At birth, according to Sisson, normally the 8 incisors and the premolars have erupted. There are no canine teeth in cattle and consequently there is a space, interalveolar (interdental) space, between the corner incisor teeth and the premolars. The premolars and the molars are normally situated in a vertical position in a straight line on the alveolar border of the mandible and maxilla.

The principal abnormality observed in the dead calves was the impaction of the premolar teeth in the mandible which was greatly reduced in length and width giving a "parrot-mouth" appearance. The defective jaw was bilaterally symmetrical. The interalveolar space was longer than is normal. The mandible was considerably enlarged where the premolar teeth were impacted, a considerable eminence being present on the buccal surface. The bulging on the lateral surface was not as prominent, but a fracture in the bone was noticeable here just posterior to the third premolar.

The space occupied by the premolar teeth was markedly reduced in length from the normal. The first premolar and its alveolus slanted anteriorly at a 45° angle. One root of the second premolar was erupted and the crown almost entirely imbedded. This tooth pointed anteriorly, its long axis forming an angle of almost 100 degrees with the normal long axis and was lateral to the anterior part of the third premolar. The third premolar was crowded to the mesial side of the jaw bone. The anterior part of the crown, lying under the second premolar, was greatly reduced in size and the anterior two-thirds of the tooth slanted somewhat anteriorly and mesially. The molar



PEDIGREE OF INHERITANCE OF IMPACTED MOLARS

Figure 16

The appearance of this defect, which causes the death of the calves soon after birth, in an inbred herd of milking Shorthorn cattle, is consistent with the theory that the defect is a simple menedlian recessive. The numbers are too small to adduce statistical proof that this is made the mode of inheritance of the character.

dental germs were in irregular positions and not at all normal in size.

The ramus of the mandible also showed slight irregularities. The coronoid process was bent toward the condyloid process and rotated to the exterior, showing poor articulation with the skull. The anterior border of the ramus was thicker than normal. The angular process also deviated from the normal, extending further posteriorly and being thicker than usual.

No other defects were noted. The incisor teeth were normal, the upper jaw normal, and gross examination revealed no pathological conditions in other parts of the body.

Inheritance of the Defect

The herd in which this defect was found was established in 1917 by the purchase of a purebred bull (I_1) and two purebred sisters. Registrations were maintained for a few years but later was discontinued. About five years later another bull (II_2) was purchased at the same farm where the foundation stock was secured. Few purchases were made and stock from within the herd was kept for breeding purposes. As the herd was small, this resulted in very close inbreeding. The appearance of defective calves in this herd ceased upon the purchase of another sire of unrelated breeding.

In only five cases could the parentage be traced accurately but altogether there were about eight cases of this defect in this herd. The close relationship of the five calves whose parentage was known is shown in the accompanying chart.

The old bull mated with one of the foundation cows sired two normal heifers. One (II_1) mated back to her sire

produced a normal heifer, but when mated to the new bull (II_2) produced a male showing the defect. Tracing down the left side of the chart, it can be seen that the defect was passed through three generations before appearing in the progeny. The other sister (II_3) mated with the new bull produced a male showing the defect, a normal female which when mated with a bull of their own breeding in turn produced a male showing the defect, and other normal progeny. Other matings also show this trait to act as a simple one-factor recessive. There were not enough matings nor enough information to compute expected ratios of normal to defective offspring and compare such ratios with those actually observed. However, it seems clear that this character is inherited as a simple recessive, the condition of impacted molars being produced by this recessive factor in a homozygous state.

Summary

The occurrence of inherited lethal characters in cattle is briefly reviewed and the condition of impacted molars, a lethal factor in Milking Shorthorn cattle, is shown to appear as if it were due to a single simple recessive gene.

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METHODS OF CLINICAL GENETICS

THIS is an introductory text* to statistical methods as applied to medical investigations. Unfortunately, many of the most recent developments are not included. The presentation is clear and readable. W. Landauer

*Schulz, B., *Methodik der medizinischen Erbforschung* (Methods of clinical genetics). 189 pages, 16 figures. Georg Thieme, Publisher, Leipzig, 1936. Paper covers 10.50 marks; cloth 12 marks.

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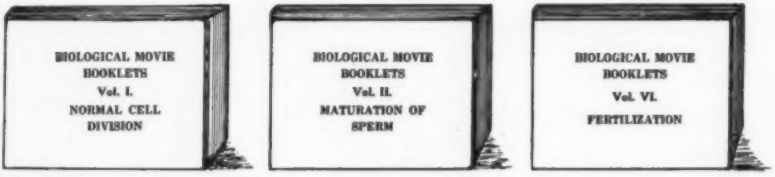
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